MECHANICAL ENGINEERING

INCLUDING THE ENGINEERING INDEX

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

The Engineer's Job

It is much discussed among engineers whether their occupation is in a true sense of the word a profession or whether it is merely a trade. The true professional attitude is one of trusteeship, not merely for the material but also for the social and spiritual interests of men. . . . The great problem of humanizing industrial life, beautifying it, spiritualizing it, is the central problem of the present era. It is a problem for the solution of which we must look to the engineers for leadership. It is a problem which furnishes justification for the liberal as well as the professional training of the engineer.

FRANK AYDELOTTE,
President, Swarthmore College

JULY 1923

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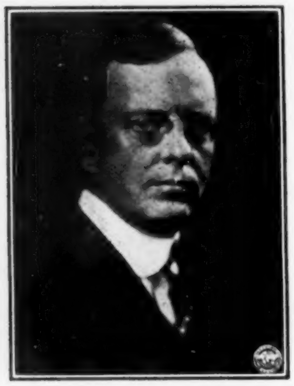
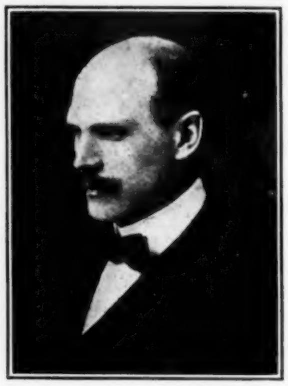


Julian C. Smith

Walter F. Rittman



Sumner B. Ely

Frederick A. Gaby

Contributors to This Issue

Sumner B. Ely and **Walter F. Rittman,** co-authors of the leading article in this issue, are former business men now connected with the Carnegie Institute of Technology. Mr. Ely was born at Watertown, N. Y., in 1869, attended the public schools in Chicago, and received his M.E. from the Massachusetts Institute of Technology in 1892. Following graduation he worked as a machinist for various companies.

In 1897 Mr. Ely went into the drafting room of the Pressed Steel Car Co., at Pittsburgh, Pa. While associated with this company he went to Egypt to superintend the erection of the first lot of steel cars shipped there, and in 1902, a year after he became chief engineer of the American Sheet Steel Co., he was sent to Germany to study continuous sheet-rolling methods. The following year, when this company was merged into the American Sheet & Tin Plate Co., he became its assistant chief engineer, and later its chief engineer. In 1905, he organized the Chester B. Albree Iron Works Co., of which he became vice-president. It was not until 1916, after the death of Mr. Albree, that he disposed of his business interests and became assistant professor of commercial engineering at Carnegie.

Dr. Rittman was born at Sandusky, Ohio, in 1883, received his A.B. from Swarthmore in 1908, and entered the business world as chemist for the United Gas Improvement Co. of Philadelphia. In 1909 he opened an office in that city as consulting engineer. For seven years, from 1914 on, he was chemical engineer with the U. S. Bureau of Mines. He became head of the Department of Commercial Engineering at Carnegie two years ago.

Dr. Rittman received his Ph.D. from Columbia, and degrees in chemical and mechanical engineering from his alma mater. Both of these men are members of the A.A.A.S. the A.S.M.E., and other engineering and scientific organizations.

* * * * *

Julian C. Smith, author of the paper on power development in Quebec, was graduated from Cornell as a mechanical engineer in 1900 and began his business career as a draftsman with Wallace C. Johnson, consulting engineer of Niagara Falls, N. Y. Two years later he was made assistant engineer to Mr. Johnson at Shawinigan Falls, Quebec. In 1903 he became superintendent of the Shawinigan Water & Power Co. of Montreal, and was rapidly promoted to his present position of vice-president and general manager, and executive of all subsidiary companies. He is also president of a number of power and public service companies in Canada.

Mr. Smith is a member of the British Institution of Electrical Engineers, the Canadian Society of Civil Engineers, and the A.I.E.E. He was recently given the honorary degree of LL.D. by Queens University, Kingston, Ontario.

* * * * *

Frederick A. Gaby, who has been with the Hydro-Electric Power Commission of Ontario since 1907, its chief engineer since 1912, is a Canadian by birth and is about forty-five years old. He is a Toronto University graduate, year of 1903. Prior to his appointment to the Commission he was with the Canadian General Electric Co., the Toronto Niagara Power Co., and various companies handling electrical installation work.

Mr. Gaby is a fellow of the Royal Society of Arts and of the A.I.E.E., and a member of the A.S.C.E., A.S.M.E., E.I.C., and many other technical organizations in Canada and the United States.

* * * * *

G. G. Bell, who contributed an article on feedwater heating, was graduated from Toronto University in 1905 as an electrical engineer and took a special course in civil engineering two years later. The intervening time he spent in the engineering office of the Canada Foundry Co. of Toronto. From 1908 to 1910 he was engaged in structural drafting and design for the Canadian Bridge Company, Walkerville, Ont., and for a like period of time handled structural and hydraulic engineering for the Sawyer-Moulton Co., Portland, Me. Mr. Bell first became associated with the West Penn Power Co. in March, 1912. He is now manager of power development.

* * * * *

Herbert W. Croizer, with the assistance of J. D. Stigen and C. E. Nagel, tells about Diesel-engine progress on the Pacific Coast. These men are all good Californians now, whatever their nativity. Mr. Crozier was born and educated in that peerless state, being graduated from the University of California in 1899. For eight years he held various positions in electrical and constructional work. During the last fifteen years he has been mechanical and electrical engineer and manager of the San Francisco district for Sanderson & Porter, San Francisco.

For the past four years Mr. Stigen has been naval architect for the Standard Oil Co. of California. Previously he was connected with the Pacific Gas & Elec. Co., and the Union Branch of the Bethlehem Shipbuilding Co.

Mr. Nagel has been chief engineer of the Pacific Diesel Engine Co., Oakland, Cal., for the past three years. He was formerly assistant district supervisor of the Emergency Fleet Corporation at New Orleans, and for ten years prior thereto was state bridge engineer of Minnesota.

Coming A.S.M.E. Events

The Montreal Spring Meeting reported in this issue of Mechanical Engineering is the last meeting until Fall. Then will occur the third regional meeting, to be held at Chattanooga, Tenn., October 23-24. The Annual Meeting will be held in New York, December 3-6.

Plans for the Chattanooga meeting include sessions on power, management, and welding. The Annual Meeting program is also well under way and an interesting four days is assured. The A.S.M.E. News will contain the advance information about these events.

MECHANICAL ENGINEERING

Volume 45 July, 1923 No. 7

Power and Fuel Consumption of the Iron and Steel Industries of the Pittsburgh District

By SUMNER B. ELY[1] and W. F. RITTMAN,[1] PITTSBURGH, PA.

THE Carnegie Institute of Technology through its Commercial Engineering Department is conducting a major investigation of present power requirements and potential future power possibilities in the Pittsburgh district (1) with relation to the community and its development as a whole and (2) with relation to the various specific industries of the community.

The largest and most important industrial activity of the district is the production of iron and steel, and the first step has naturally been to make a detailed study of that industry with relation to its power requirements.

Some idea of the quantity of steam used by the steel industry within the 30-mile-radius circle around Pittsburgh can be had from the following interesting comparison with the Superpower Survey for the region between Boston and Washington lately published by W. S. Murray and others. If the boiler horsepower-hours as shown in the Pittsburgh power-study curve for the year 1920 [see curve (*b*), Fig. 2] are put into equivalent kilowatt-hours, it will be found that this figure is about two-thirds of the total kilowatt-hours for the same period as given in the Superpower Survey for the whole district covered by it.

The value of such a survey lies (1) in the importance of the Pittsburgh district as a factor in the nation's steel production, and (2) in the fact that the data will serve as a basis of comparison when corresponding data are collected for other steel centers. Furthermore, any development in the use of or in the creation of power for the steel industry is of vital concern to the other industries of the community, and, in fact, of interest even to concerns located within a radius of 100 miles or more from Pittsburgh. Finally, it was felt that a detailed study of power and fuel consumption in the steel industry in a district as important as that embraced by this investigation would give some indication as to the general trend of developments during the period covered, and there is good reason to believe that this expectation has been justified.

Points Brought Out by the Survey

The data presented show certain marked developments in the power phase of the steel industry. First, they reveal a greatly increased use of given equipment—expressed by the increased load carried by each unit of physical equipment; and secondly, a marked increase in cost of fuel for the development of power, as well as a period of inefficient fuel use coinciding with the war years. The curves drawn from data obtained in this survey indicate the volume and importance of power as a factor in determining steel production costs. A continuation of such curves will register changes in efficiency, while the accurate cost data obtained will undoubtedly be useful for future planning.

The Pittsburgh undertaking has taught a valuable lesson in regard to what might be called the art of making industrial surveys. It is obvious that the value of such a survey is primarily dependent on the ability of those making it to ascertain the facts which shall form the foundation of the deductions later made, and what is perhaps even more important, the ability to ascertain *all* the facts and not merely those easily accessible, and to express them in a comparable manner and in sufficient detail to enable one to obtain a clear insight into their significance.

In this connection it appeared early in the study that some of the institutions investigated either did not have the necessary facts properly collected or were reluctant to give detailed data as to their costs, fuel and power consumption, efficiency and so on, on the ground that their organizations might show up unfavorably in comparison with others, or that because of their size they would be accused of monopoly in their particular branch of the industry.

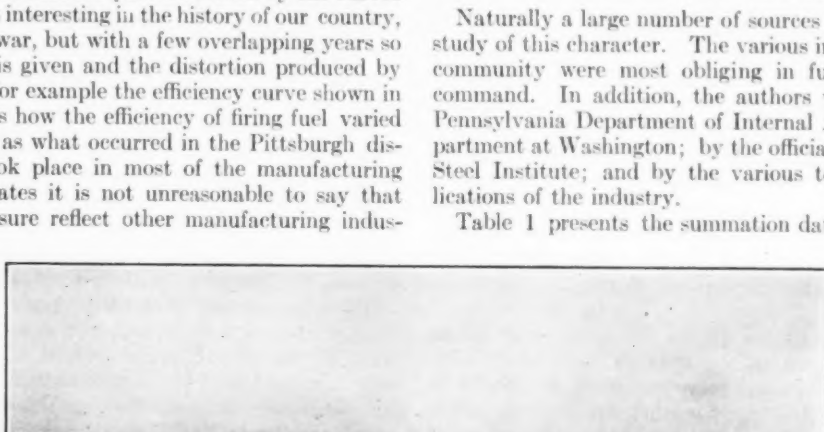
There was no way of compelling compliance with the request for facts, and even if there had been it would have been probably extremely unwise to have employed it. It was decided that the only way to collect the data was to obtain it from the individual companies, which meant that, speaking colloquially, the idea of the survey had to be "sold" to these companies, and that the various institutions involved had to be instilled with sufficient faith in the Carnegie Institute of Technology to entrust it with this confidential detailed information. This situation was met by a general agreement that no specific data referring to individual companies would be published and that all the data would be used only in combination so that only summation or overall figures would be shown.

In the spirit of confidence and mutual goodwill thus created it became comparatively easy to meet the next obstacle, namely, that different institutions used different units of measure and different ways of keeping records, which made interpretation difficult. This was done by the various parties involved joining about a common table and placing their respective engineers in conference for the common end. For instance, in the case of the public utilities, the data and trends were developed by engineers from the various utilities in counsel with the Carnegie Institute of Technology. There are indications that these conferences and the work done on the survey may lead to a greater completeness and uniformity of power- and fuel-consumption records in the steel industry of the

[1] Professors of Commercial Engineering, Carnegie Institute of Technology.

Pittsburgh district. Further, the work has effectually shown that the community or industrial inventory can be made only with the complete coöperation of the community and industry.

In general, it will be noted that the period covered by the curves presented is one of the most interesting in the history of our country, namely, that of the world war, but with a few overlapping years so that an idea of the trend is given and the distortion produced by the war indicated. Take for example the efficiency curve shown in Fig. 13 (*a*), which indicates how the efficiency of firing fuel varied during the war years and as what occurred in the Pittsburgh district is typical of what took place in most of the manufacturing districts of the United States it is not unreasonable to say that these curves in great measure reflect other manufacturing industries; so that by the study of these curves we can learn something, broadly speaking, of the condition of the whole country.



Again, a tendency to work equipment beyond its capacity is distinctly shown at the beginning of the war—possibly because additional equipment could not be obtained promptly—and later on an increase in equipment is evident. This undoubtedly reflects the general conditions then prevailing in most manufacturing industries, and while this agrees with general opinion, the curves provide a definite, concrete verification.

Furthermore it must not be forgotten that power is approximately proportional to production, and that the curves indicate in general the demand for steel and iron. The general rise in the price of fuel has not been confined to the Pittsburgh district, so that the percentage increase in the cost or price of fuel gives a fairly good idea of what happened throughout the United States, or the eastern half of it at least.

Defining the Pittsburgh District

The corporate limits of the City of Pittsburgh long ago proved inadequate to hold the manufacturing establishments and plants which now spread up and down its rivers and arteries of transportation. They are much more restricted than those of most metropolitan districts, but serve as the hub of the fifth major district of the country and embrace a population of over 1,200,000. The area selected for this study was that of the circle struck with a radius of thirty miles from the Pittsburgh City County Building as the center (see Fig. 1), because the people and the iron and steel plants comprised within it are intimately associated with and largely dependent upon the facilities of corporate Pittsburgh.

Summary of the Data Presented

Naturally a large number of sources of information are used in a study of this character. The various iron and steel interests of the community were most obliging in furnishing the data at their command. In addition, the authors were helped greatly by the Pennsylvania Department of Internal Affairs; by the Interior Department at Washington; by the officials of the American Iron and Steel Institute; and by the various technical journals and publications of the industry.

Table 1 presents the summation data covering the more important items entering into this study. To the business man the figures given in this table are valuable as covering the more important elements and relationships entering into the industry, but to the iron and steel engineer or the power engineer the detailed data and relationships are of equal if not greater interest. Column 1 shows the total gross tons of fuel, coal equivalent, used under boilers; column 2 the cost of this fuel, and column 3 the gross tons of ingots produced with this fuel. The three succeeding columns cover data derived from the first three columns. These data show that as the number of gross tons of steel ingots rose from approximately ten million in 1911 to thirteen million in 1920, the value of the fuel used under boilers increased from less than seven million dollars to more than twenty-nine million. On the other hand, the fuel used per gross ton of ingots produced increased only from 0.57 ton to 0.60 ton, and the value of fuel used per gross ton of steel ingots produced increased from \$0.65 in 1911 to \$2.27 in 1920.

The Rated-Capacity Curve, Fig. 2 (*a*), represents the boiler capacity of all the iron and steel plants in the District. The curve shows practically no increase in the installed boiler capacity during the years 1914 to 1917, but a tendency in that direction since 1918. In no case has the increase in boiler capacity been in proportion to the increase in production; in other words, increased producing capacity was attained largely by the harder and more efficient use of the existing equipment.

The Output Curve, Fig. 2 (*b*), gives, in boiler horsepower-hours, the total quantity of steam produced per year by the installed rated capacity shown by curve (*a*). By superimposing curve (*b*),

on curve (*a*), the extent to which greater utilization was secured from existing equipment becomes evident.

The Coal Used is shown in Fig. 2 (*c*), and is the tonnage actually fired under the boilers to produce the steam shown by curve (*b*) of the same figure. This curve appears to correspond closely with curves (*a*) and (*b*) in showing a fall in 1914 and then a greatly increased activity through 1920. A pronounced peak is evident during 1918. Personal investigation has developed the fact that much of this increase was not the result of efficient expansion. During that period fireman as a group showed a considerable labor turnover with resultant inefficiency in the use of a given volume of fuel, and considerable coal of less desirable character was used. Facts like these are not shown in the statistics but are of primary importance.

The Total Value of the Coal Used is shown in Fig. 3 (*a*). The rise in this curve from 1915 to 1918 is greater than the rise for the same period in the tonnage curve, Fig. 2(*c*), reflecting that the price per ton was advancing during the period—as might well have been expected from the demand at that time. The total amount of money paid for boiler coal during the year 1920 was in excess of $20,000,000.

The Price of Boiler Coal per gross ton throughout the period is shown in Fig. 4 and was derived by dividing the values of curve (*a*), Fig. 3, by the tonnage volume of curve (*c*) Fig. 2. The price variation during the period is vividly portrayed. A persistent upward tendency running from $0.955 in 1911 to $4.10 per gross ton in 1920 accords with the trend of all commodities during the period.

The Total Blast-Furnace Gas Used under boilers is shown in Fig. 5. In order to have a better basis of comparison, the cubic feet of a gas are expressed in terms of coal equivalent. The ratio used is 103 B.t.u. per cubic foot of gas to 13,500 B.t.u. per pound of coal.

The Value of the Blast Furnace Gas Used, Fig. 3 (*b*), was estimated by valuing the quantities shown in Fig. 5. Considerable difference of opinion naturally existed as to what this value should be. A few years ago blast-furnace gas, being a by-product, was considered as of small value. Today, however, iron and steel manufacturers distribute a book charge for this gas, generally against the power plant, which is right and proper. The generally-agreed-upon value of the coal equivalent is $1.35 per ton, but in 1920 this figure was changed to $3.27. The weakness of such empirical assumptions is recognized, but so long as the basis of calculation is understood, each reader can revise the conclusions as he may see fit.

The Natural Gas Used under the boilers in the iron and steel industry is shown in Fig. 6 (*a*). The amount consumed was very small, and prior to 1918 was of such small volume as to be negligible.

The Cost of Natural Gas Used under boilers is shown in Fig. 6 (*b*), and during 1919 was only about $3000, an amount so small as to be of little importance in the total figures. The curves show that the average cost of the 18,000,000 cu. ft. used during 1919 was 18 cents per 1000 cu. ft. More natural gas probably would have been used by the industry had it not been for regulations exercised by the producers and distributors of natural gas by which domestic users were given priority.

The By-Product Tar Used as boiler fuel is shown in Fig. 7 (*a*), and, as in the case of the natural gas, was negligible when compared to the total fuel consumed. The tar is expressed in terms of coal equivalent on the ratio of one pound of coal containing 13,500 B.t.u. and one gallon of tar containing 168,000 B.t.u.

The Value of the Tar Used as boiler fuel is shown by curve (*b*) of Fig. 7.

In the Pittsburgh District considerable gas is generated by the by-product coke ovens for use in open-hearth furnaces. At Clairton alone more than 13,000 tons of coal are being coked daily in by-product ovens, and the capacity of this plant is now being doubled. While some of this gas is occasionally diverted to boilers because of shutdowns of furnaces and some is used for what is known as "regulator gas" to take care of slight shortages that may arise, the quantity is so small as to be negligible in the fuel totals for boilers under consideration.

Fig. 1 The Pittsburgh District Studied, which Embraces the Area Within a Radius of Thirty Miles from the City's Center

The Total Quantity of Fuel Used under the boilers of the iron and steel manufacturers in the Pittsburgh District is shown in Fig. 8. The upper curve, which represents a summation of the coal, gas, and tar used, has much the same shape as that of the lower one, which covers coal only and is reproduced on a different scale from Fig. 2 (*c*). There was a decided upward trend in the fuel consumption of the industry from 1911 to 1920 which corresponded generally with the increase in iron and steel production during that period.

The Percentages of Coal and Blast-Furnace Gas Used for power purposes are shown in Fig. 9. The curve is based on the coal equivalent for blast-furnace gas as compared with the coal, and appears to be fairly constant in the ratio of 60 per cent coal to 40 per cent gas. This ratio is important because it shows that through the efficient use of the blast-furnace gases they can be substituted for 40 per cent of the coal which otherwise would be required.

The Total Value of All Fuels Used under the boilers of iron and steel manufacturers in the District is shown by Fig. 10. Comparing this curve with curve (*a*) of Fig. 3 which shows the same data for coal only, it will be observed that the proportion and trend in blast-furnace-gas consumption is such as not to materially change the slope of the curve. It clearly brings out the upward trend in the value of power fuel since 1911. Starting at about $5,250,000 in 1911 there was comparatively little change until 1915, when a marked increase occurred during the war years, with a decrease from 1918 to 1919 and a further considerable rise until the value reached more than $29,000,000 in 1920, or an increase of more than 500 per cent during the ten-year period.

The Value of a Unit of Fuel is shown in Fig. 11. This value comprises coal and blast-furnace gas, the natural gas and other fuels being negligible. The curve further shows the proportionate

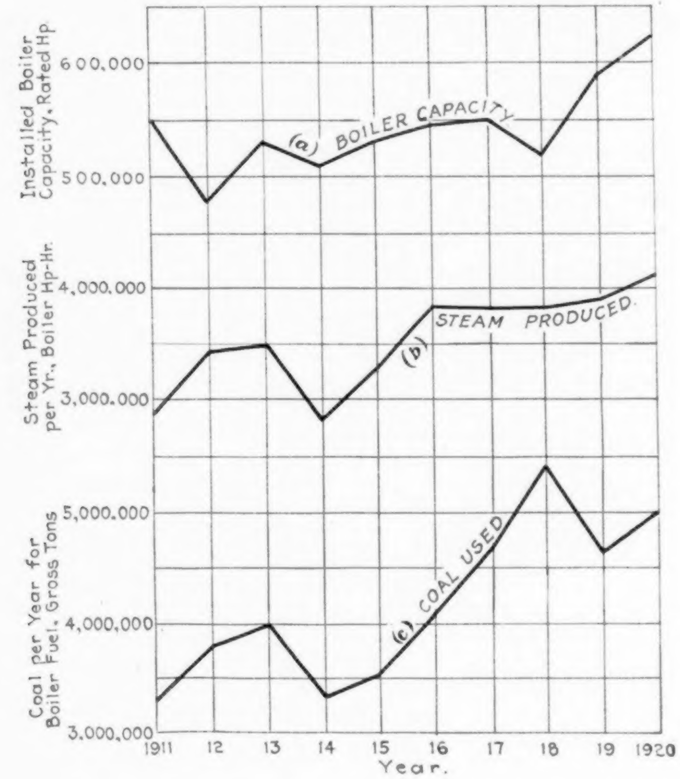


Fig. 2 Curves Showing (a) Total Rated Horsepower Capacity, (b) Total Quantity of Steam Produced, and (c) Coal Used for Boiler Fuel in All Steel Works of the Pittsburgh District

(Note: 1 hp. rated capacity = 10 sq. ft. of heating surface.)

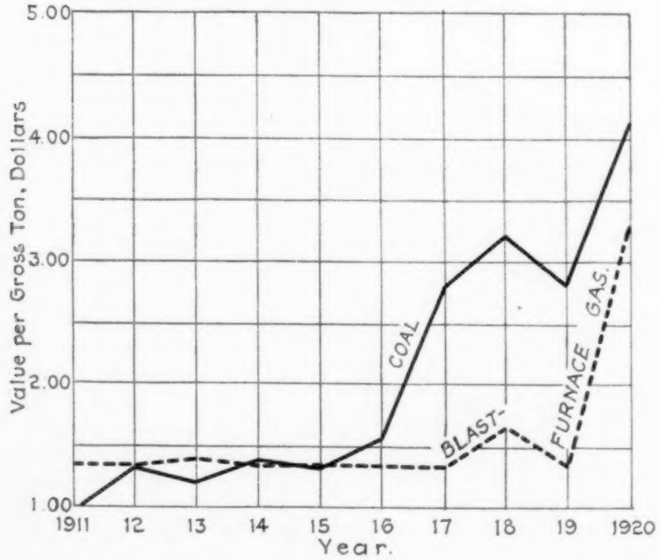


Fig. 4 Curves Showing Value per Gross Ton of Coal and Blast-Furnace Gas Used as Boiler Fuel in All Steel Works of the Pittsburgh District

(Note: Value given for a "gross ton" of blast-furnace gas is for the quantity of gas that will develop the same amount of heat as one gross ton of coal.)

values of coal and blast-furnace gas which go to make up the unit value. The unit taken is a gross ton, the blast-furnace-gas equivalent coal value being used as previously stated.

The percentage shown by Fig. 9 makes the blast-furnace-gas equivalent coal used not greatly less than the actual coal used, whereas the values in dollars show the blast-furnace gas to be valued at a much smaller figure than the coal. This is a question of bookkeeping as before stated. It would seem logical that blast-furnace gas should be given a higher value to make its variations more nearly correspond with the variations in coal prices. In this

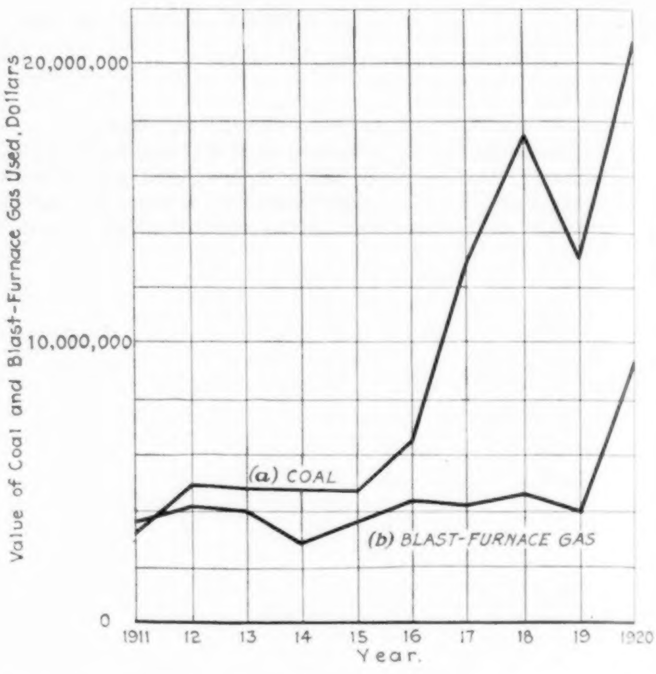


Fig. 3 Curves Showing Value of Coal and Blast-Furnace Gas Used for Boiler Fuel in All Steel Works of the Pittsburgh District

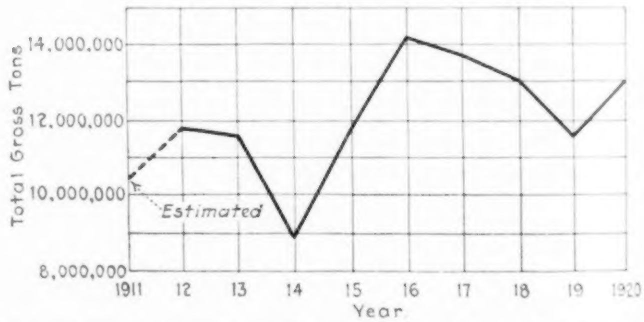


Fig. 5 Curve Showing "Gross Tons" of Blast-Furnace Gas Used for Boiler Fuel in All Steel Works of the Pittsburgh District

(See note under caption of Fig. 4.)

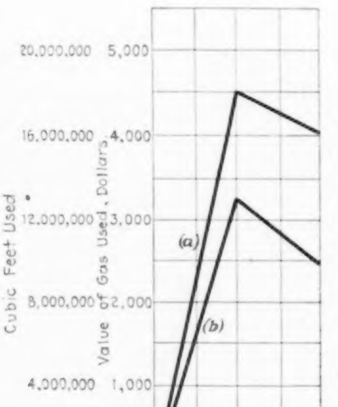


Fig. 6

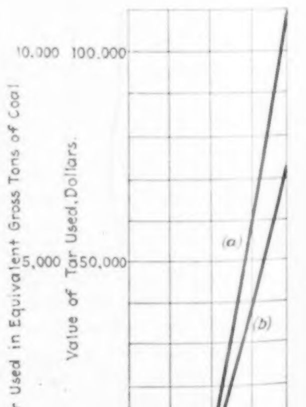


Fig. 7

Fig. 6 Curves Showing (a) Quantity and (b) Value of Natural Gas Used for Boiler Fuel in All Steel Works of the Pittsburgh District

Fig. 7 Curves Showing (a) Quantity and (b) Value of Tar Used for Boiler Fuel in All Steel Works of the Pittsburgh District

(Note: A "gross ton" of tar is the quantity of tar that will develop the same amount of heat as one gross ton of coal.)

TABLE 1 FUEL CONSUMPTION, STEEL PRODUCTION, AND GENERAL DATA ON STEEL WORKS OF THE PITTSBURGH DISTRICT

Year	Gross tons of fuel used under boilers	Value of fuel used under boilers	Gross tons of steel ingots produced	Gross tons of fuel used under boilers per gross ton of steel ingots produced	Value of fuel used under boilers per gross ton of steel ingots produced	Value of one gross ton of fuel used under boilers
1911	5,920,000	$ 6,500,000	10,400,000[1]	0.57	$ 0.65	$ 1.10
1912	6,850,000	9,200,000	11,800,000	0.58	0.78	1.35
1913	6,850,000	9,200,000	11,600,000	0.59	0.79	1.35
1914	5,470,000	7,400,000	8,900,000	0.61	0.83	1.35
1915	6,280,000	8,300,000	11,700,000	0.54	0.71	1.34
1916	7,400,000	10,900,000	14,100,000	0.53	0.77	1.48
1917	7,830,000	17,300,000	13,700,000	0.57	1.26	2.22
1918	8,250,000	21,700,000	13,000,000	0.63	1.67	2.63
1919	7,270,000	17,000,000	11,600,000	0.63	1.47	2.34
1920	7,830,000	29,500,000	13,000,000	0.60	2.27	3.76

[1] Estimated.

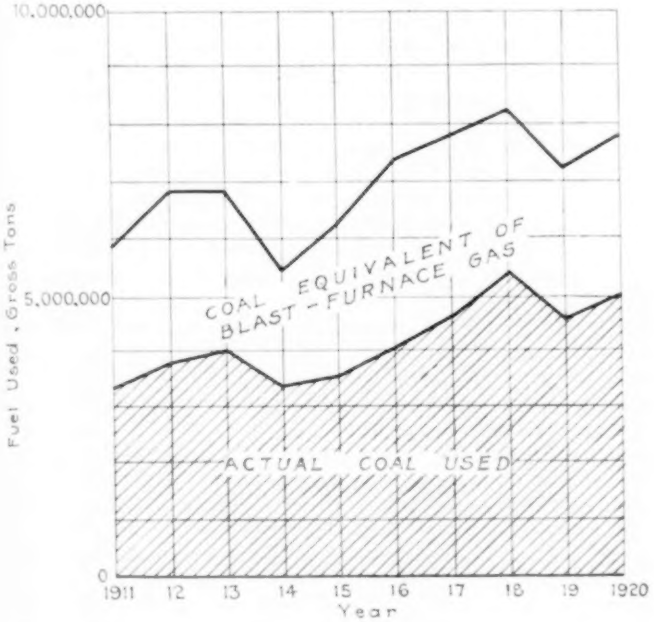


Fig. 8 Curve Showing Total Quantity of Fuel Used Under Boilers in All Steel Works of the Pittsburgh District

(Note: See note under caption of Fig. 4.)

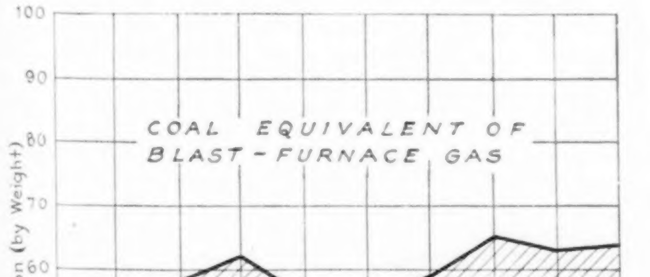


Fig. 9 Curve Showing Percentage Composition (by weight) of the Average Gross Ton of Fuel Used Under Boilers in All Steel Works of the Pittsburgh District

(Explanation: In 1916, e.g., one gross ton of average boiler fuel consisted of 55 per cent coal and 45 per cent blast-furnace gas. See note under caption of Fig. 4.)

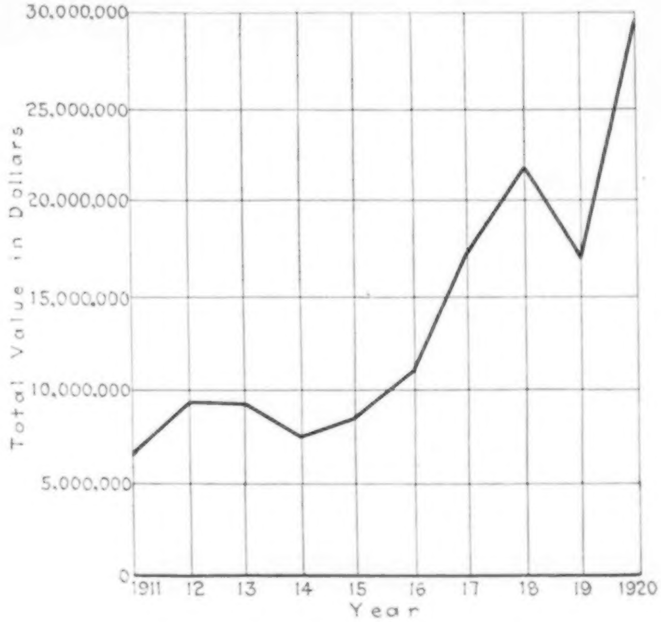


Fig. 10 Curve Showing Value of Fuels of All Kinds Used Under Boilers in All Steel Works of the Pittsburgh District

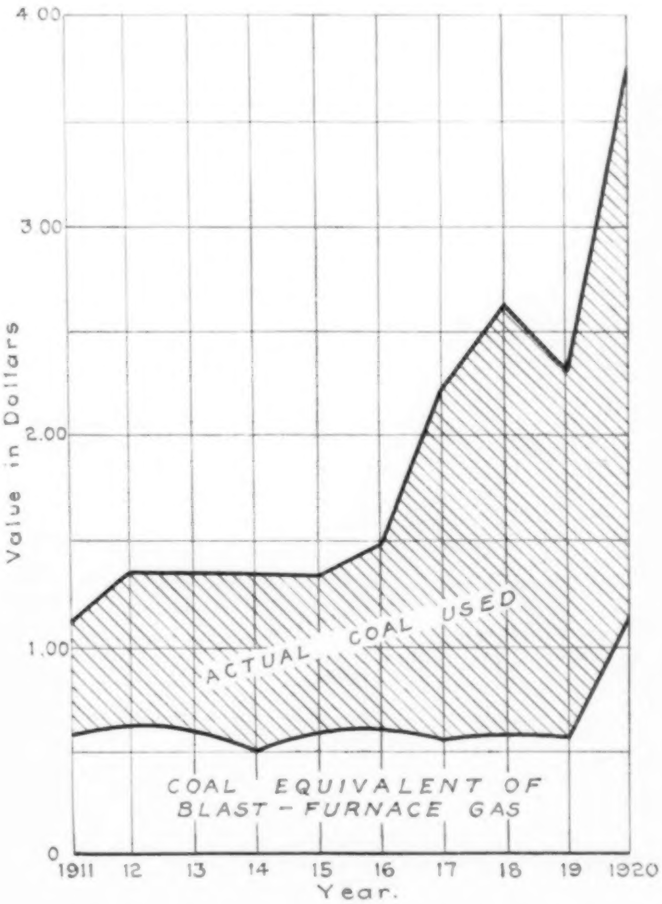


Fig. 11 Curve Showing Value of One Gross Ton of Fuel Used Under Boilers in All Steel Works of the Pittsburgh District

(Explanation: In 1916, e.g., one gross ton of average steam fuel consisted of 61 cents' worth of blast-furnace gas and 87 cents' worth of coal, making the fuel equivalent of one gross ton of coal cost $1.48. See note under caption of Fig. 4.)

study, however, it was considered advisable to follow more nearly the practices of the industry.

The Total Tonnage of Iron and Steel Produced in the Pittsburgh District during the years 1911 to 1920 is taken as the total weight of ingots produced during that period and is given in detail in Table 1, and expressed in the form of a curve in Fig. 12. These figures were

largely derived from the American Iron and Steel Institute for the later years, whereas for the earlier years a canvass was necessary to secure data covering each individual plant in the District.

It was considered advisable to use ingots as a basis of weights in connection with the production of the iron and steel plants, because it was deemed impracticable to use records of finished tonnages since the latter practice inevitably involves much duplication and confusion of data.

The curve as a whole shows a decided upward trend in keeping

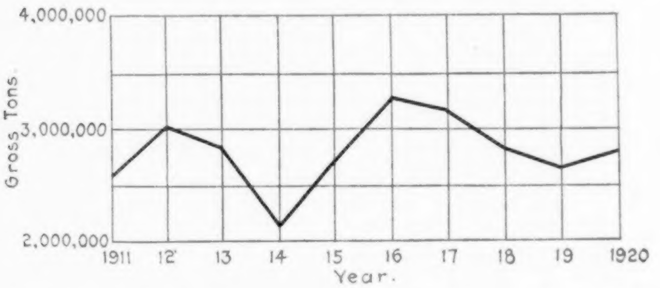


Fig. 12 Curve Showing Total Quantity of Steel Ingots Produced per Year in All Steel Works of the Pittsburgh District

with the trend in general production. On the other hand, the ten-year period covered is probably too brief a one upon which to base conclusions as to the proportion of increase that the Pittsburgh District is responsible for in the industry as a whole.

The Quantity of Power Fuel per Ton of Steel is shown by curve (*a*) of Fig. 13. Variation in this curve resulted either from the use of less desirable fuels or variations in the efficient utilization of the fuels available. Details regarding the efficient use of fuels cannot be shown in general-data figures, but are worthy of special study.

Fig. 13 Curves Showing (*a*) Quantity and (*b*) Value of Fuel (Coal plus Blast-Furnace Gas) Used Under Boilers per Gross Ton of Steel Ingots Produced in all Steel Works of the Pittsburgh District

The Cost of Power Fuel per Ton of Steel is shown by curve (*b*), of Fig. 13, which represents the data of curve (*a*) translated into dollars and cents and indicates how the price of fuel advanced during the latter half of the period. It will be noted that in 1911 the cost of power fuel to manufacture a gross ton of ingots was 65 cents, whereas by 1920 this same figure had mounted to $2.27, an increase of more than 300 per cent.

The data presented show two marked developments in the power phase of the industry: first, the increased load carried by each unit of physical equipment; and second, the marked increase in cost of fuel for the development of power. Many other equally interesting observations and comparisons can be made for the ten-year period, but because of the different viewpoints of those interested in the industry, the authors prefer to leave the wide variety of interpretations possible to such individuals or groups.

From the beginning the steel industry has had to depend on its own organization for its power, for at the outset there were no adequate sources of, or means of transporting to the plant, the large quantities required, and long before any knowledge of electrical generation and transmission it was recognized that the sources of power in the industry itself necessitated their utilization at the plant, so that we have today in every steel works a power plant, frequently in many units, generating in all of its several phases most of the power required to carry on the various operations from raw materials to finished steel products.

During comparatively recent years tremendous development has been made in the size, reliability, and control of electrical apparatus for steel-plant service, and in the generation and transmission of the power required for its operation. Its almost innumerable applications have been so general in character and large in total that in many cases the development of the plant's own power supply has not kept pace either in economy or size with the peak power demand, so that electric current frequently must be purchased to take care of these maximum-load periods. It is only natural to expect that still further applications of power, both electric and steam, will be made in the ever-constant development of the steel industry so that its power plant will ever become increasingly important.

Unfortunately, power does not appear on our cost sheets as a single total item, and we are apt to think of power costs only to the extent that they do appear as separate items of steam, electricity, water and air, not always remembering that power is the total of all of these, plus the additional power costs that are necessarily included in our cost-sheet figures, in raw materials for their handling, in partly worked materials, power for shops appearing as repairs, and many other auxiliary operations. The result is that the true cost of power is not generally fully appreciated, total power cost being defined as the cost of producing or purchasing all the energy for generating steam, electricity and blast-furnace blowing. In such a cost, waste heat must be accorded a value commensurate with the value of the fuel that would have to replace it if the waste heat were not available.

The author gives a tabulation of cost data taken from the cost records of three of the Bethlehem Steel Company's plants. This tabulation covers the period from Jan. 1, 1920, to Aug. 1, 1922, considered as representative. From this tabulation the importance of the power item in steel making appears plainly.

Any single cost item that stripped of all credits reaches the proportion of early one-fifth of the total plant payroll, or $5^1/_2$ per cent of the total sales value of all manufactured products, or twice the cost of all refractories, commands attention. How to reduce it, and the extent to which it can be reduced, constitute the real economic question.

In general, there are three points of attack on the problem after the cost analysis has been made; first, on the prime movers of mill and auxiliary drives; second, on the electric generating and blast-furnace blowing plants; and third, on the steam plants. For new installations there is little room for argument against electrification as showing the greatest economy. For existing steam-driven units practically every case will show a fair return on the investment by the substitution of electric drive, including the generating equipment.

In general, steelworks have not taken full advantage of the economies possible in connection with the operation of electric generating stations and blast-furnace blowing plants. (Abstract of paper read by E. F. Entwisle, Mem. A.S.M.E., before the *American Iron and Steel Institute* published in *The Iron and Coal Trades Review*, vol. 106, no. 2882, May 25, 1923, p. 784)

Hydroelectric Possibilities of Quebec

The Potential and Actual Hydroelectric Development of the Province of Quebec and Its Probable Rate of Growth in the Future

By JULIAN C. SMITH,[1] MONTREAL, CANADA

THE OBJECT of this paper is to present briefly the potential and actual hydroelectric development of the province of Quebec, and so far as may be done from the progress in the past, to estimate the probable rate of development of the hydroelectric resources in the future.

The province of Quebec comprises that vast stretch of territory lying east of the Ottawa River and north of the United States boundary line, bounded on the north by Hudson Strait, on the west by Hudson Bay, and on the east by Labrador. It is 2000 miles in width from north to south and 1350 miles from east to west, having an area of 706,804 square miles, or almost 25 per cent of that of the United States. The northern section is for the most part uninhabited, but the southwestern portion lying along the lower part of the Ottawa and St. Lawrence Rivers, and extending south to the American border and east to the Saguenay River, is an important and rapidly growing industrial section.

If we superimpose a map of the province of Quebec over a map of the eastern portion of the United States, Quebec will cover the states from the Atlantic Ocean west to Chicago including the Great Lakes, and from North Carolina to Canada, leaving some 200,000 square miles of the northern part of the province overlapping Canada.

The climate of Quebec is quite similar to that of northern New England. The winters are severe, and snow covers the ground from the middle of November to the end of March. The summers are warm and pleasant, and the precipitation, which is fairly evenly distributed over all seasons, averages about forty inches per year.

The Watersheds of the Province

Topographically the country north of the St. Lawrence River is divided into three great watersheds. South of the river and west of the town of Levis, which is opposite the city of Quebec, the country is a low-lying fertile plain; east of the town of Levis the land rises gently to between 1000 and 2000 ft., with elevations of nearly 5000 ft. in the Gaspé Peninsula. On this south side of the river there are no large waterpowers as the watershed is comparatively narrow and, although well watered, is traversed by only a few rivers of any magnitude.

The three great watersheds lying to the north of the St. Lawrence River are the south watershed, draining into the St. Lawrence River; the north watershed, into the James and Hudson Bays; and the east watershed, through Labrador into the Atlantic Ocean. Of these the south watershed, through which flow the tributaries of the St. Lawrence from the Ottawa to the Notashkwan, is the most important. The height of land dividing the north and south watersheds lies some 200 miles north of the St. Lawrence and runs roughly parallel to it. On either side of this height of land there is a vast plateau having a mean elevation of from 1200 to 2000 ft. which begins at the Ottawa with a width of some 150 miles and spreads out like a fan toward Labrador where it attains a width of 500 miles or more. The southern edges of this plateau are for the most part near the St. Lawrence so that the rivers which traverse it make their sharpest descent to sea level not far distant from the main river, and as a consequence much of the water power of this watershed is within easy reach of the industrial section of the province.

The north watershed is drained by many large streams flowing into James Bay, and when the development of the country has progressed far enough to permit their waterpowers to be utilized, enormous amounts of power will become available on the Nottaway, Rupert, East Main, and Kaniapiskau Rivers.

[1] Vice-president and general manager, Shawinigan Water and Power Co.

Presented at the Spring Meeting, Montreal, Canada, May 28 to 31, 1923, of The American Society of Mechanical Engineers. Slightly abridged. All papers are subject to revision.

With regard to this northern watershed, although the area is large the precipitation is largely unknown, and the run-off also is largely a matter of speculation.

The east watershed is drained principally by the Hamilton River, on which is situated a water power estimated at 700,000 hp. at Great Falls, some 350 miles from the mouth of the river and 200 miles north of the St. Lawrence River at the west end of Anticosti Island.

The ultimate source of the water power of any country is the precipitation, and the total potential water power produced thereby may be estimated by calculating the potential energy of this precipitation in its descent from the highlands to the sea.

Potential Water Power of the Province of Quebec

To calculate the total potential water power of the province of Quebec we may superimpose a map of the precipitation upon a topographical map of the province and then divide the province into areas having the same average elevation and approximately the same precipitation. An estimate of the potential energy due to precipitation can then easily be made. The precipitation in inches per year at different points of the province is as follows:

Montreal	40	Shawinigan	37.61
Quebec	40.5	Chicoutimi	30
Brome	34.3	Anticosti Island	36
Father Point	33.58		

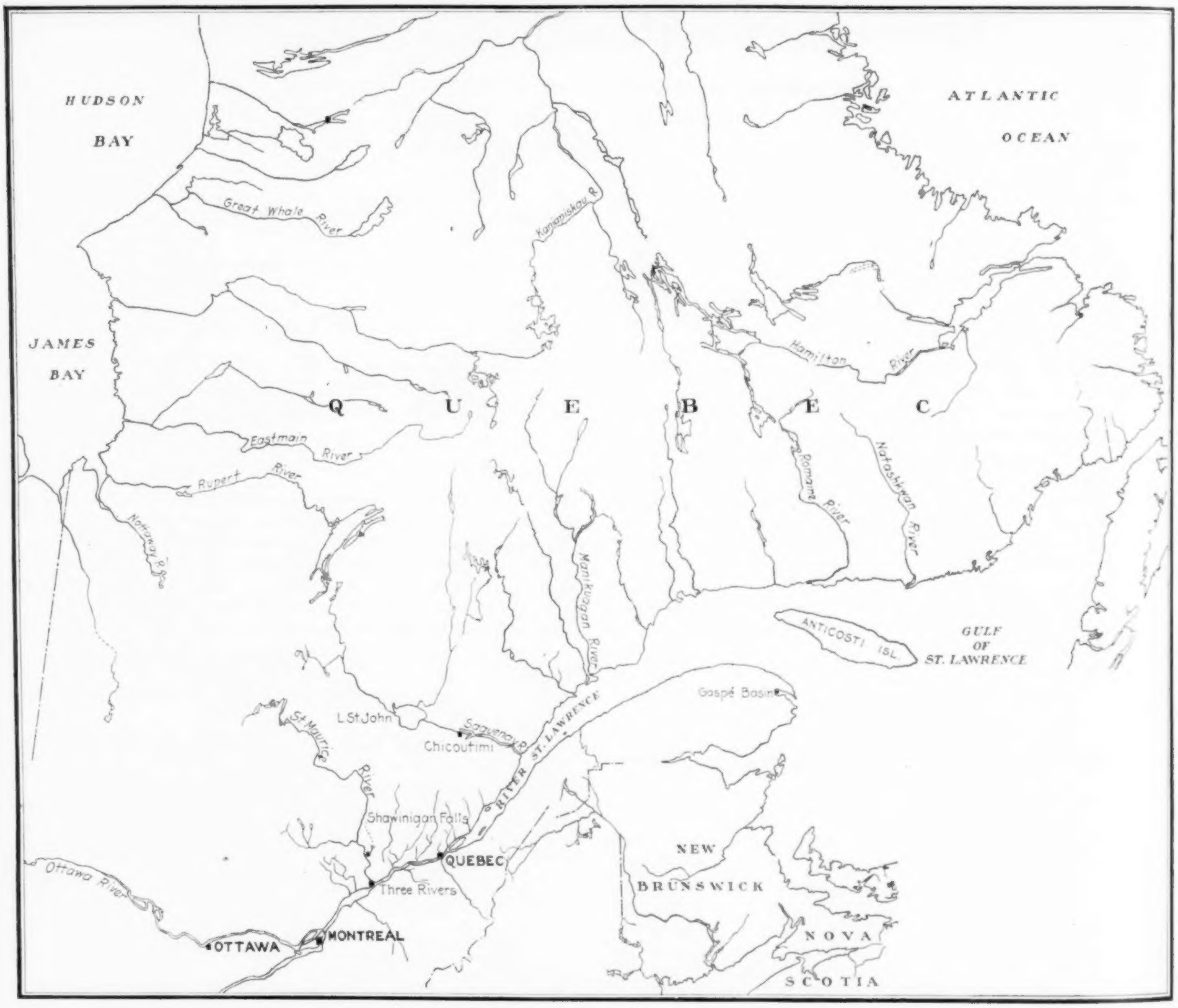
The total area of the province is as stated above roughly 700,000 square miles, of which for the present purpose we may neglect the triangular area cut off by a line drawn from the northern tip of Labrador to the southern end of James Bay containing some 200,000 square miles of snow-covered land, leaving a net area of 500,000 square miles. This area of 500,000 square miles may be divided into four plateaus of different elevations and slightly different rainfall, as follows:

Average precipitation per year in inches	Average elevation in feet	Area in square miles	Equivalent continuous power in kw.
40	1700	170,000	71,400,000
40	1000	220,000	92,400,000
35	500	100,000	18,350,000
40	300	10,000	1,260,000
		500,000	183,410,000

Mr. C. P. Steinmetz, in a paper read before the American Institute of Electrical Engineers in 1918, made a similar computation showing the potential water power from the rainfall in the United States between the thirtieth and fiftieth parallels of latitude and found that over an area of 2,970,000 square miles the potential power was 1000 million kilowatts of continuous power. Prorating the figures obtained above for the province of Quebec, the potential water power of the province due to the precipitation is about 10 per cent higher per square mile of area than the average potential water power of the United States.

It is of course obvious that this amount of power is not available because no water would be left for vegetation, and even were all hydroelectric developments carried out, no allowances have been made for losses due to seepage and evaporation.

If we average the figures for the various stations throughout the province, we arrive at an estimated run-off for the whole province of 18 in. per year. Substituting this figure for the total precipitation, we obtain a total of 88.7 million kilowatts of continuous power, and allowing an efficiency of conversion of 60 per cent from the stream to the distribution center, there remains 53 million kilowatts of continuous power as the maximum possible hydroelectric power which could be produced if during all seasons every drop of water which ran off the 500,000 square miles of territory considered were converted into hydroelectric power. This is of course an impossible condition, as there would be no flowing streams



Map of Quebec Showing Watersheds and Rivers

in the country but only lakes and canals connected together by penstocks discharging through turbines into those of lower levels.

In estimating the amount of power which is actually available we must obviously neglect the energy in the water falling on the upper plateau, which is lost in the first part of its descent from these highlands.

While it is impossible to state accurately the percentage of energy loss before the gathering together of water takes place, it may be conservatively estimated at 50 per cent on an average over the many steep and shallow valleys that go to make up the different drainage basins.

We must also subtract from the total of available energy all the energy consumed by friction of the banks and beds of the rivers and streams, which is sufficient to use up about one-half foot of head per mile on the average; and in addition we must consider as non-available all the energy contained in those portions of the rivers and streams and brooks where the fall is hardly greater than that necessary to produce the required flow of water through the channel. In this class will be included practically all the lower reaches of the main rivers and those tributaries which unite with them below the points of greatest descent.

As continuity of supply is an essential condition to all power service, due allowance must be made for the fact that while the precipitation is more or less equally distributed during the year, the run-off from the precipitation is most unequally divided among the different seasons. During the spring thaw the melting and running away of the accumulated winter snowfall produces flood conditions on all rivers and streams, raising the flow to as much as 20 to 100 times the minimum. The necessary waste of the greater part of the water reduces still further the quantity of energy which may be considered as available for industrial uses, even under ultimate conditions of development.

Combining the sources of lost energy enumerated we may assume that not more than 25 per cent of the 53 millions of kilowatts of energy contained in the total run-off could be converted into electric energy, and therefore that the actual potential energy of the province of Quebec is approximately thirteen to fifteen millions of continuous kilowatts.

In the present state of the art of the development and distribution of hydroelectric power, only those sites near industrial centers and at which water power exists in considerable quantities are capable of being developed. The theoretical available quantity of fifteen to eighteen million kilowatts of continuous power must therefore be very considerably reduced in estimating the quantity of power that is actually adaptable to industrial purposes. From recent surveys of the water powers of the province, and considering only those rivers on which water power is available in such quantities and in such locations as could be economically developed either now or in the near future, the quantity of actually available water power in the province is estimated at approximately 5.25 million kilowatts of continuous power, of which some 800,000 kilowatts have now been developed and utilized. There remains,

therefore, in the Province of Quebec as available commercial water power about 4.5 million kilowatts of continuous power or about 12 million horsepower at 50 per cent load factor.

The Quebec Streams Commission of the Province of Quebec, and the Water Powers Branch of the Department of the Interior at Ottawa, have published during the past several years valuable articles giving detailed information regarding the available water powers, and particularly those which can be developed within the next few years from an economic standpoint.

The Load Factor

The various amounts of power mentioned in this paper thus far have been described as "continuous power," which means that the flow of water producing this power is sufficient to provide the full quantity twenty-four hours a day, three hundred and sixty-five days in the year, and here the author proposes to digress for a moment from the main subject of the paper to discuss briefly the subject of "load factor," or the proportionate duration of use of power.

It must be borne in mind that no industry is able to make continuous use of the power which it requires, and that therefore no power company supplying power for industrial purposes is called upon to supply the total amount of contracted power all day every day in the year. The term "load factor" is used as a measure of the duration of use of power and is defined as average power divided by peak power. The load factors of the various industrial loads in Quebec differ considerably. For instance, paper mills operate a load factor of between 65 and 75 per cent, averaging more nearly 65 per cent; carbide and electrochemical plants operate at 85 to 90 per cent; cement mills at 80 to 90 per cent; and asbestos and mining industries at 45 per cent load factor. The load factor of a hydroelectric station supplying various industrial establishments and providing power and lighting service to communities will obviously be the average of the combined load factors of the various loads. Such a plant will therefore not require to use continuously the flow of its water which will produce maximum output. Provided sufficient water-storage capacity exists, the surplus energy that the normal flow of the river could produce may be stored in the form of water, but otherwise a certain portion of the available energy—which might be very great at certain seasons in the year—must be allowed to run to waste. In estimating the amount of energy available for industrial uses from the flow of the river at a given head, due consideration must therefore always be given to the storage capacity of the watershed and to the amount of regulation of flow which is possible with full utilization of the storage capacity.

TABLE 1 PRINCIPAL WATER-POWER DEVELOPMENTS IN THE PROVINCE OF QUEBEC

River	Location	Company	Available Head, ft.	Total Generating Capacity, hp.
In Operation				
St. Maurice	Shawinigan Falls	Shawinigan Water & Power Co.	150	195,000
	Shawinigan Falls	Northern Aluminum Co.	145	40,000
	Grand Mere	Laurentide Power Co.	84	160,000
St. Lawrence	St. Timothee	Quebec-New England Hydraulic Corpn.	50	21,000
	Cedars Rapids	Montreal Light, Heat & Power Co.	32	229,200
	Soulanges		50	15,000
	Lachine Rapids		14	13,000
Richelieu	Chambly	Montreal Light, Heat & Power Co.	...	31,000
Ottawa	Hull	Ottawa and Hall Power & Mfg. Co.	40	20,000
		E. B. Eddy Co. (private)	...	10,000
St. Francis	Drummondville	Southern Canada Power Co.	32	6,700
Montmorency	Montmorency Falls	Quebec Ry., Light, Heat & Power Co.	270	5,000
St. Anne	Seven Falls	Laurentian Power Co.	410	20,000
Under Construction				
Saguenay	Lake St. John	Quebec Development Co.	300	400,000[1]
St. Maurice	Gres Falls	Shawinigan Water & Power Co.	65	132,000
Ottawa	Calumet Island	Ottawa and Hull Power & Mfg. Co.	60	60,000

[1] A further 800,000 hp. will be developed later near the mouth of the river.

In plants where no storage capacity exists, the installation of sufficient generating capacity to consume the increased flow of water during the six high-water months becomes economically justifiable by the use of electric steam generators as an adjunct to the plant to make possible the utilization of the excess energy produced during these months by its conversion into steam. The ability to obtain a return from all the energy available at all times of the year will make possible the development of many power sites which, if dependent solely upon the sale of continuous electric power as such, might remain undeveloped.

Early Water-Power Developments

The earliest water-power developments in the province were the old seigniorial mills constructed by the French seigniors to grind the grain of their dependents. These little grist mills were in existence as early as 1650, and were almost always developed by the construction of a small canal which carried the water to an overshot or undershot wheel where the heads used varied from about five or six feet up to ten or fifteen feet.

The first hydroelectric development was the Montmorency plant near the mouth of the Montmorency River, seven miles below Quebec, built in 1895 and having an installed capacity of five 600-kw. generators.

This was followed in 1897 by the St. Narcisse plant on the Batiscan River, with an output of 750 kw. which was transmitted to Three Rivers over a two-phase 12,000-volt transmission line 18 miles long. This was the first high-tension line in the British Empire.

The Chambly plant on the Richelieu River, 17 miles from Montreal, was built in 1898 with four 2000-kva. machines, the output of which was transmitted to Montreal at 25,000 volts, three-phase; and in the same year the Lachine Rapids plant was put into operation with a maximum output of 10,000 kw., at certain times of the year only.

Principal Water Powers Now in Operation

The principal water powers now in operation in the province of Quebec may be divided as follows: Powers on the Ottawa River; powers on the St. Lawrence River, Province of Quebec; powers on the St. Maurice River; powers on the Saguenay River and its tributaries in the vicinity of Chicoutimi; and powers located on the south side of the St. Lawrence River, particularly on the St. Francis River and its tributaries.

The two great developments existing today in this province are located at Cedars Rapids in the St. Lawrence River, thirty miles west of Montreal, and on the St. Maurice River at Shawinigan Falls and Grand Mere. The third great power, which ultimately may eclipse these, is now being constructed on the Saguenay River just below the outlet of Lake St. John.

In addition to the developments enumerated in Table 1, which generate electricity for use in public-utility service or for industrial service in the neighborhood of power developments, there are a large number supplying power for grinding wood. These latter are widely scattered throughout the province, most of them having been built prior to 1910. The total amount of hydraulic power used directly for this purpose in the province has been stated by the Water Power Branch to be 162,825 hp. With the advent of the vertical turbine and the increase in the size of electrical generating units, it became in many cases more economical to develop the power in the form of electricity to be transmitted to pulp and paper mills built in favorable positions rather than to locate the mills at the site of the power development. The amount of hydroelectric power so used is stated to be 157,367 hp., making a total of 320,192 hp. of hydraulic turbines employed in the pulp and paper industry.

Difficulties Encountered in Water-Power Engineering

There are certain difficulties occurring in water-power engineering in this province which meet engineers in every locality where the climatic conditions are similar to those which obtain in its latitude. Ice troubles in the past have caused serious interruptions of service and reductions in the available amount of power. These troubles may be divided into two broad divisions:

a Ice troubles occurring in the power house itself, due to the presence of ice on the racks on the waterwheels

(Continued on page 429)

Hydroelectric Developments in Ontario

Present and Projected Developments of Hydroelectric Power in the Province of Ontario, Together With Particulars Regarding the Largest Single Hydroelectric Development in the World, the Queenston-Chippawa Installation

By F. G. Gaby,[1] Toronto, Ont.

The province of Ontario is richly endowed with water powers, widely distributed over an area of over 400,000 square miles, and its surface waters drain both to the Atlantic and to the Arctic oceans. The water-power possibilities of the streams draining through the Great Lakes system to the Atlantic have been fairly well ascertained, but much remains yet to be known regarding the power possibilities of the streams draining through Hudson Bay into the Arctic. However, preliminary estimates which include Ontario's share in the water powers of her international waters have indicated a total of some 6,000,000 hp., of which about 1,300,000 hp. has already been developed.

The Chief Water Powers of Ontario and Their Strategic Situation

The power potentialities of the Niagara and St. Lawrence Rivers constitute a very large proportion of the available power in the watershed, tributary to Lake Ontario. There are nearly thirty sites, of which about one-half have been developed with an aggregate capacity of 50,000 hp., leaving undeveloped sites with an aggregate capacity of some 15,000 hp. Tributary to Lake Huron are water-power streams with an aggregate potentiality at known sites of nearly 300,000 hp., of which about 100,000 hp. is developed. Tributary to Lake Superior are water-power streams with an aggregate potentiality of about 300,000 continuous hp. About half of this total is on the Nipigon River, on which an initial development has been made for the municipalities of Port Arthur and Fort William by the Hydro-Electric Power Commission of Ontario. The outflow from Lake Superior through St. Mary River constitutes an important water-power site, which has been partially developed. In the extreme west of the province, the English and Winnipeg rivers, which flow into the province of Manitoba, have important water powers; in Ontario these powers aggregate over 250,000 hp.

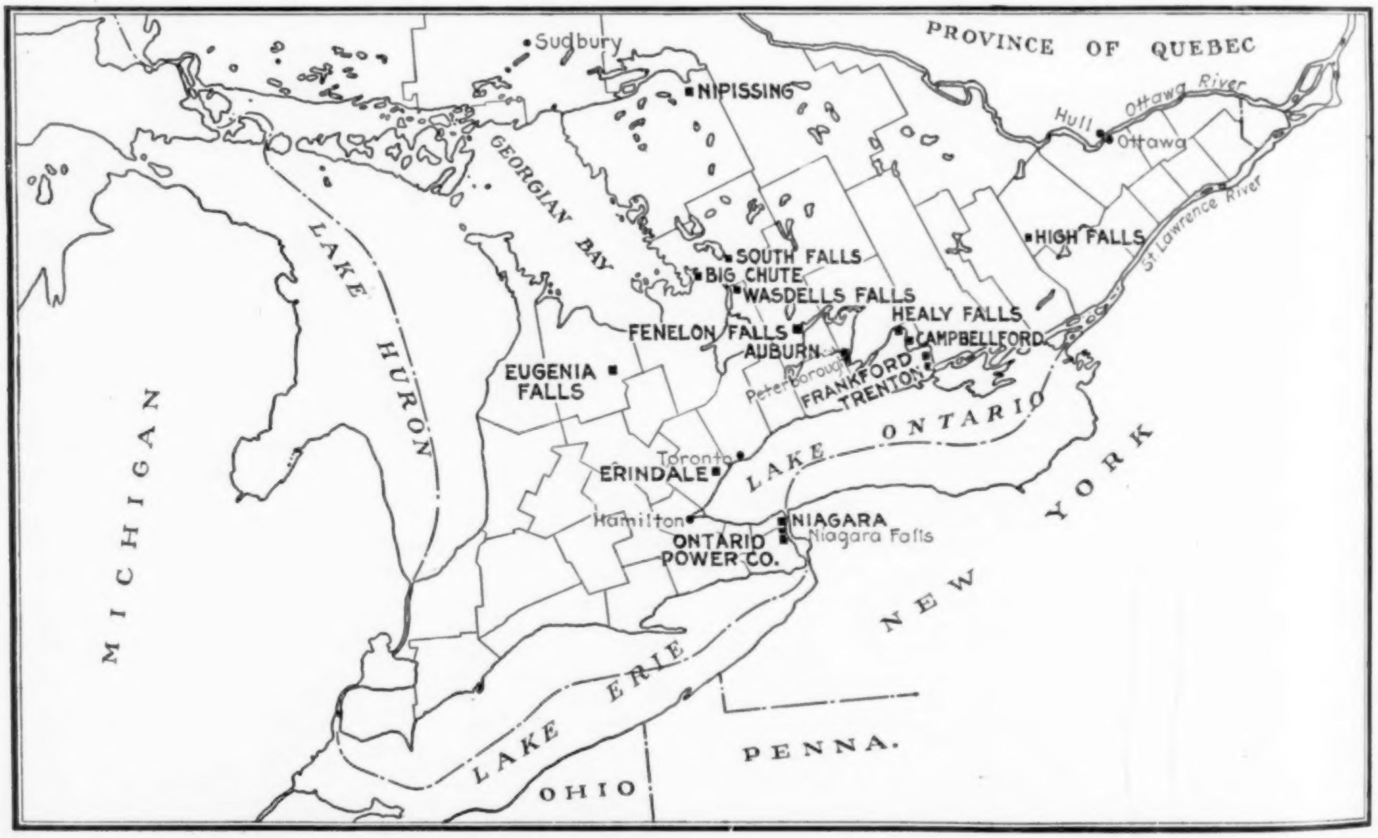


Fig. 1 Map of Ontario, Showing Watersheds and Rivers

province. Next in importance is the Ottawa River and its tributaries. The power on the main stream, which constitutes part of an interprovincial boundary, is shared by the provinces of Ontario and Quebec. Under conditions of controlled flow, Ontario's share of the power available on the main stream, together with that on the tributaries in Ontario, aggregates about 700,000 hp.

Other important water powers are found in the Trent River There remain to be mentioned the water powers of the streams flowing from Ontario into James Bay and Hudson Bay. The more important of these streams from the viewpoint of water-power possibilities are the Mattagami, the Abitibi, the Missinaibi and the Albany Rivers. These streams have not yet been adequately appraised; the total water-power possibilities of known sites aggregate upward of 1,000,000 hp.

What, at the present time, however, is of much greater importance to the province of Ontario than its total water-power possibilities, is the fact that in its commercial centers where the greater proportion of the population resides, are situated the largest and most important water powers.

[1] Chief Engineer, Hydro-Electric Power Commission of Ontario. Mem. A.S.M.E.

Presented at the Spring Meeting, Montreal, Canada, May 28 to 31, 1923, of The American Society of Mechanical Engineers. Abridged. All papers are subject to revision.

Ontario has no natural supply of coal and has been compelled to import this necessity—both bituminous and anthracite—chiefly from the state of Pennsylvania. The rising cost of this fuel and the fact that manufacturers have been dependent upon outside sources for their supply, have been phases of the power situation in the province which have greatly stimulated, and which doubtless will continue to stimulate, the utilization of the water powers of the province along the lines of hydroelectric development.

Early Hydroelectric Developments in Ontario

The most important *early* hydroelectric development in the province of Ontario from the standpoint of magnitude and extensive transmission, was the plant at DeCew Falls. This plant takes its water from Lake Erie at the level of the upper reach of the Welland Canal at Allenburg. It is a high-head development (265 ft.) of about 50,000 hp. capacity. Current is generated at 2400 volts, 3-phase, 66 cycles, and transmitted at 44,000 volts. The main objective of this DeCew power was the city of Hamilton, in the industrial life of which it has played a most important part.

Niagara Falls. The three large hydroelectric plants at Niagara on the Canadian side of the river have often been described in print, but in view of the subject in hand, it is believed that a brief reference should be made to these developments because of their importance to the general hydroelectric economy of the province of Ontario.

In 1889 negotiations by a group of United States capitalists with the Queen Victoria Niagara Falls Park Commission eventuated in the formation of the Canadian Niagara Power Company—an ally of the Niagara Falls Power Company of Niagara Falls, New York. The water for this plant is drawn from the level of the upper river through an intake canal, and is thence distributed to the intake chambers at the head of each penstock. The penstocks pass vertically down an everage depth of about 160 ft. to the turbines The water finds its outlet to the lower level of the river in the gorge below the falls. The nominal installed capacity of this plant, including a spare unit, is 121,000 hp. The ground was broken for the tunnel on October 4, 1890, and the first commercial power was delivered to the Pittsburgh Reduction Company for the reduction of aluminum ore on August 26, 1895.

The next important development at Niagara was that of the Ontario Power Company, which commenced operation by the delivery of commercial power in 1905. This plant has its intake near the Dufferin Islands, above the falls. The water is conveyed a distance of over 6000 ft. to penstocks by means of underground conduits. The plant operates under an average effective head of about 180 ft. and its present capacity is a little over 160,000 hp. In 1917 the Hydro-Electric Power Commission acquired the whole ofthe as set including the generating plant at Niagara Falls, of the Ontario Power Company. This plant is now operated by the Commission.

In 1903 the Electrical Development Company entered into an agreement with the Commissioners of the Queen Victoria Niagara Falls Park whereby the company was to utilize the waters of the Niagara River for the development of 125,000 e.hp. Its plant is situated above the falls and about midway between the headworks at Dufferin Islands of the Ontario Power Co. and of the Canadian Niagara Power Co. The plant operates under a head which varies from 130 to 145 ft., dependent upon river conditions. In 1922 the assets of the company, including the development just described, were acquired by purchase by the municipalities of the Niagara district, and the operation of the plant was placed under the jurisdiction of the Hydro-Electric Power Commission.

There is a demand for the total output of these Niagara plants which represent in their day the highest state of the art to which hydroelectric development had attained. The splendid service given by these installations under the exacting conditions of overload—especially during the period of the great war—reflects great credit upon the engineers and manufacturers responsible for their design and construction.

New Ontario Developments. In the Sudbury, Cockrane, and Cobalt districts of what is known as New Ontario there are several developments on the Metabitchawan, Montreal, Metagami, and Wahnapatie Rivers which aggregate approximately 60,000 hp. and are used for general municipal purposes and the operation of gold, silver, cobalt, copper and nickel mining properties in Northern Ontario. The pulp and mining companies have their own developments to the extent of 125,000 hp. located on the Abitibi, Spanish, Vermillion, Magnetawan and the Onaping Rivers, which they use for their own manufacturing purposes.

Systems and Power Developments of the Hydro-Electric Power Commission

Having now reviewed the outstanding features of hydroelectric development in the province of Ontario, we may next devote attention to some of the more interesting characteristics of the power developments which supply electrical energy to the various systems

TABLE 1 CAPACITY OF PRESENT AND PROJECTED DEVELOPMENTS OF THE HYDRO-ELECTRIC POWER COMMISSION OF ONTARIO

	—Present Plants—		Projected Developments
Present Development or Site	Present capacity, hp.	Ultimate capacity, hp.	Estimated hp.
Niagara System			
Niagara River:			
Ontario Power Co	180,000	150,000	...
Electrical Development Co	125,000	100,000	...
Queenston-Chippawa Development	300,000	550,000	...
Canadian Niagara Power Co. (purchased power)	20,000	20,000	...
Total	625,000	820,000	...
Combined Northern Systems—Severn, Eugenia and Wasdells			
Beaver River:			
Eugenia Falls Development	8,500	8,500	...
Severn River:			
Wasdells Falls development	1,200	1,200	...
Big Chute development	6,200	6,200	...
Port Severn	...	...	1,400
Saugeen River:			
Haywards Falls	...	...	1,020
Port Elgin	...	...	10,000
Kimberley	...	...	1,700
Total	15,900	15,900	14,120
Muskoka System			
Muskoka River:			
South Falls development	1,750	6,000	2,000
Total	1,750	6,000	2,000
St. Lawrence System			
St. Lawrence River:			
Cedar Rapids Power Company (purchased power)	...	...	...
Morrisburg and Long Sault	...	...	600,000
Total			600,000
Rideau System			
Mississippi River:			
High Falls development	3,600	Fully developed	...
Carleton Place development	735	Fully developed	...
Ragged Chutes	...	...	3,600
Total	4,335	...	3,600
Thunder Bay System			
Nipigon River:			
Cameron Falls development	25,000	75,000	...
Alexander Landing	...	...	41,900
Pine Portage	...	...	40,400
Virgin Falls	...	...	30,800
Kaministikwia River:			
Silver Falls (Dog Lake)	...	...	22,000
Total	25,000	75,000	135,100
Ottawa System			
Ottawa River:			
Ottawa and Hull Power & Mfg. Co. (purchased power)	...	20,000	...
Chats Falls	...	...	60,000
Total	...	20,000	60,000
Central Ontario and Trent System			
Developments above Rice Lake	11,140	...	...
Developments below Rice Lake	40,470	...	10,720
Total	51,610		10,720
Nipissing System			
South River:			
Nipissing development	2,500	Fully developed	...
Bingham's Chute	...	...	1,300
Elliotts	...	...	1,150
Gitzlers	...	...	2,160
Cox's Chutes	...	...	1,930
Gimballs	...	...	700
French River: (three developments)			
Chaudiere, Five Mile Rapid, and the Dalles	...	...	30,000
Total	2,500		37,240
Grand Total .... 1,858,125 hp.			

Fig. 2 The Queenston-Chippawa Development

of the Hydro-Electric Power Commission to which reference has just been made. In this connection special attention will be directed to certain features of some of the developments installed under the administration of the Commission.

From an initial investment in 1910 of some $3,750,000 the operations of the Commission have extended until at the present time it administers properties to the value of approximately $200,000,000 delivering upward of 625,000 hp. to 14 different systems in various parts of Ontario and serving 350-odd municipalities, the systems comprising some 3500 miles of transmission lines.

Transmission Voltages. The frequency employed is 25 cycles in the Niagara system and 60 cycles in all other systems. In the Niagara System the main high-tension lines are operated at 110,000 volts and are carried on steel towers. The secondary distribution from the main transformer stations to the various municipal and distribution stations is chiefly at 13,200 and 26,000 volts, although other voltages are employed. Outside of the Niagara system the only 110,000-volt lines are in the Thunder Bay district where about 70 miles of wood-pole line are operated at this voltage. The main transmission lines of the Severn, Eugenia, Wasdells, and Muskoka systems are operated at 22,000 volts; the St. Lawrence system and the Rideau system lines at 26,400 volts; the Central Ontario and Trent system lines at 44,000 volts—recently raised from 26,400 volts, at which some lines still operate—and the Nipissing system lines at 22,000 volts. Local distribution in the various systems is usually at 2200 and 4000 volts, the service voltages being 110, 220 and 550.

The extent of the hydroelectric developments by the Commission, both actual and conjectural are summarized in Table 1.

Storage. The rapidly increasing demand for electrical energy in all of the fourteen systems operated by the Commission has in some instances already used the available water supply, while in other systems it is only a matter of two or three years or even less, before practically all of the power available under existing conditions of water supply will be requisitioned. The Commission will be able in some cases to increase the supplies available by providing storage. Most of the drainage basins supplying existing developments are well furnished with lakes and reservoir possibilities. The potentiality of the storage available as well as the potentialities of remaining power sites are being investigated by the Commission's engineers, it being recognized that such storage as may economically be developed will be demanded at an early date.

The Queenston-Chippawa Development

It is now proposed to describe some of the important features of the largest development in Ontario, in fact, the largest single hydroelectric development in the world, namely the Queenston-Chippawa installation.

The Queenston-Chippawa development, which was placed in service on February 11, 1922, is the latest addition to the Niagara system operated by the Hydro-Electric Power Commission of Ontario. This development will have a normal operating head of 294 ft. to 305 ft. when the installation is complete, which is over 90 per cent of the fall between Lake Erie and Lake Ontario. The conservation of head effected by the reduction of hydraulic losses to a minimum and by refinements in the design of the various essential elements of the project as a whole, has resulted in the production of a power development which is believed to represent the best in modern engineering practice.

The plant when completed will consist of ten 60,000- to 65,000-hp. units running at 187.5 r.p.m. and generating power at 12 kv., three-phase, 25 cycles, which in turn is transformed to 110 kv. for transmission with an ultimate capacity of 575,000 to 650,000 hp.

A glance at Fig. 2 will indicate the relation of the various works comprising the development. Water is taken from the Niagara River about one mile above the falls, is conveyed through the improved section of the Welland River, a distance of $4^1/_2$ miles, thence by a canal $8^1/_2$ miles long to the forebay and screen house located on the Niagara River about one mile south of the village of Queenston. From the screen house, steel penstocks encased in concrete carry the water down the cliff to the power house, from which it passes to the Niagara River.

The Intake. On the Niagara River one of the great obstacles to securing continuity of service is the annual formation and flow of ice. In order to eliminate as far as possible interference of operation due to ice, a special form of intake has been provided.

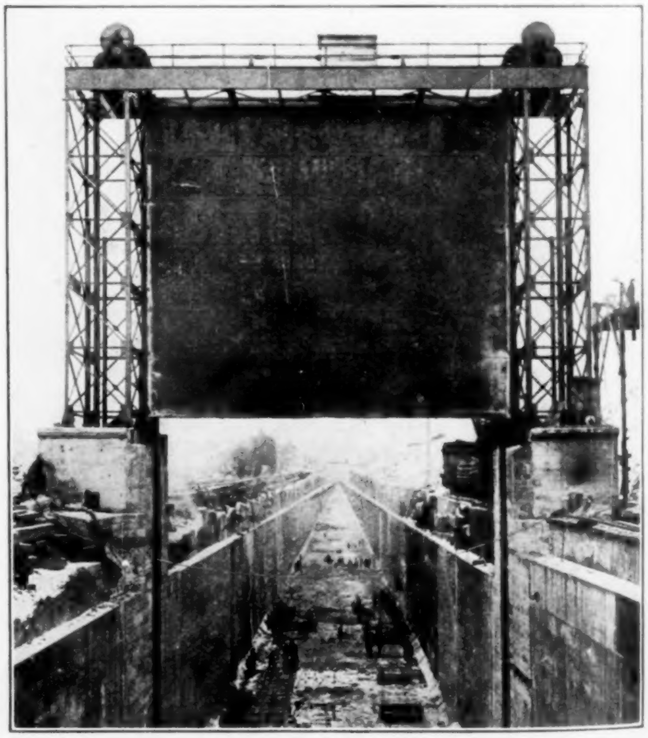


Fig. 3 Control Gate at Upper End of Canal

The complete structure is approximately 1100 ft. in length and is made up of an entrance with lock gates for navigation, a bulkhead section, and the intake proper, the latter combining two forms of intake; the conventional or surface intake consisting of a concrete barrier or boom with fifteen openings each 18 ft. in width, normally having 8 ft. of submergence, which submergence however, can be

increased, by means of drop gates to any amount up to the full depth of water or 35 ft.; and the submerged intake consisting of gathering tubes or draft distributors, six in number and 675 ft. in length.

Control Gate. Fig. 3 shows the control gate located at the upper end of the canal, where the earth section merges into the rock section. This is the largest single-leaf, roller-type, motor-operated gate ever built. It is motor-operated by means of a worm drive connected to double hoisting gears on the top of the end towers. Roller chains pass over these gears connected at one end to counterweights and at the other to the gate. When raised to its full height it leaves a clearance of 14 ft. above the water level in the canal, which will permit the passage of patrol tugs throughout the length of the waterway.

The total pull on the two chains in raising the gate is 316,000 lb. The chains are made up of pairs of links 9 in. by $1^1/_4$ in. in cross-section, and rollers $4^1/_2$ in. in diameter. The speed of lift is 4.6 ft. per min., thus requiring 12 min. to operate the gate from closed to full open position.

Concrete Lining. Economic considerations prompted the lining of the canal with concrete averaging 20 in. in thickness. The height of the lining was fixed slightly lower than the profile of the water surface existing when the load conditions on the plant are a maximum and the Niagara River flow is a minimum. Thus at all times the lining will be protected by submergence against the action of frost.

Screen House. At the lower end of the forebay, and serving as a dam for the same, is located the screen house. This structure forms the entrance and the control for the penstocks. The entrance to each of the main penstocks is a modified bell mouth consisting of three openings 12 ft. 8 in. wide and 29 ft. high at the rack supports. These three openings gradually converge into one opening 16 ft. in diameter at the point of connection to the penstock. Immediately behind the curtain wall, steel-lined gate checks are provided to support structural-steel gates.

On account of the provision of Johnson valves at the lower end of the penstocks, permanent gates were not installed in the screen house at the entrances to the penstocks. Movable gates have been provided consisting of sectionalized leaves which can be dropped into checks in the piers by means of the 25-ton traveling crane in the screen house. Concrete piers divide the entrances to the penstock into three openings, and the drop gates for closing these openings are made in three sections.

Penstocks. From the screen house the water is carried to the turbines in steel-plate penstocks. The economical diameter for units 1 to 5 was determined to be 15 ft. and in order to simplify the field riveting the lower third of the penstock was made 14 ft. and the upper two-thirds 16 ft. This decrease in the diameter at the lower end permitted the use of plates $1^1/_4$ in. in thickness, which could be readily riveted in the field. The total weight of each penstock is 840,000 lb.

Each penstock ring is made up of two plates with longitudinal joints on the horizontal center line, the plates varying from $^1/_2$ in. at the top section to $1^1/_4$ in. in thickness at the lower section. These joints are all double butt joints, varying from double riveted at the top to quadruple riveted at the lower end. The circumferential joints are also single-butt, double riveted with the butt strap on the outside. The longitudinal joints are calked on the inside, but the circumferential joints are made watertight by electric welding. This type of circumferential joint gives a very much better alignment to the inside of the pipe than can be obtained with the usual outside and inside course with lap joints. In designing the penstocks a stress of 12,000 lb. per sq. in. was used, this figure being taken to provide for the exigencies of corrosion, fatigue,

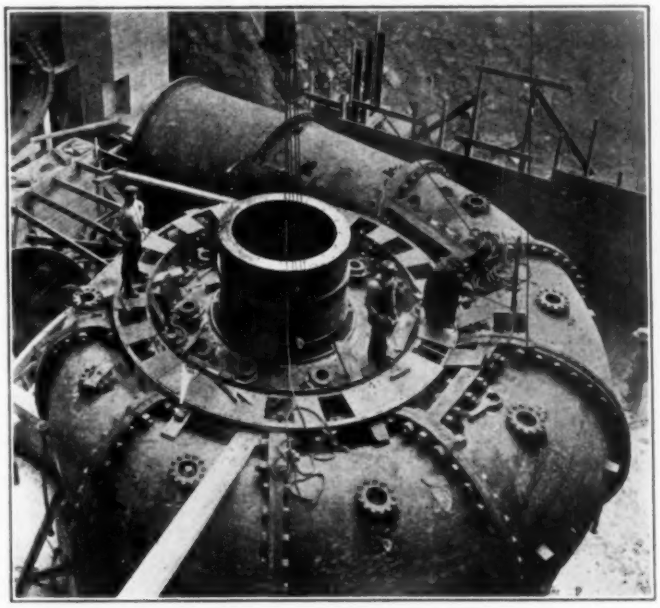


FIG. 5 TURBINE CASING ERECTED IN PLACE

suddenly applied loads, and other indeterminate or unknown contingencies. The internal pressure used for design purposes was taken to be the static head plus the pressure rise due to a complete closing of the turbine gates in $1^1/_2$ sec. This increase in pressure was taken as a maximum at the turbine gates and varying uniformly to zero at the racks.

The penstocks are covered throughout their entire length with a concrete envelope having a minimum thickness of 24 in., which protection will, it is believed, greatly increase the life of the steel pipes.

For discharging ice which may form on the canal and forebay, a chute has been provided at the south end of the screen house leading down the cliff and under the power house to the Niagara River. This ice chute is 10 ft. in diameter, made of reinforced concrete and provided at the upper end with a drop gate.

FIG. 4 VIEW OF POWER HOUSE FROM THE RIVER

Generating and Transformer Station. The generating and transformer station (Fig. 4) is located below the escarpment and close to the river's edge. As will be observed, the station extends about one-half the distance to the top of the escarpment. The structure required to house five main units and the service equipment is 350 ft. long, and ultimately this length will be doubled. The substructure is of massive concrete construction carried down to rock foundations, and provides chambers and tunnels for housing and giving access to various kinds of apparatus. The superstructure consists of a structural-steel framework with reinforced-concrete floors and roofs, and concrete, brick, and tile walls and partitions.

Turbines and Governors. Turbines Nos. 1 and 2 are designed for 52,000 hp. and Nos. 3, 4, and 5 for 55,000 hp., all at 305 ft. head, the speed being 187.5 r.p.m. They are of the single-runner vertical

type, set in spiral cast-steel casings. The inlet diameter of the casings is 10 ft. In Nos. 1 and 2, manufactured by the Wellman-Seaver-Morgan Company, of Cleveland, the casings are divided into nine sections with a separate speed ring, while in Nos. 3, 4, and 5, manufactured by the Wm. Cramp & Sons Ship & Engine Building Company, of Philadelphia, the speed ring is cast integral with the casing and the whole divided into 12 sections. The weight of the casing and speed ring in Nos. 1 and 2 is 240,000 lb., while in 3, 4, and 5 it is 180,000 lb.

The runners are made of cast steel in one piece and provided with special renewable seal rings. Those for Nos. 1 and 2 are 125 in. in diameter, and those for Nos. 3, 4, and 5 are 121 in. in diameter.

The gate control is the usual double-regulating-cylinder type operating through rods to a shifting ring connecting to the individual gates through specially designed breaking links.

All parts of the turbines adjacent to rotating elements and to water passages subjected to high velocities are made of special steel and renewable. The main-journal guide bearing on each unit is

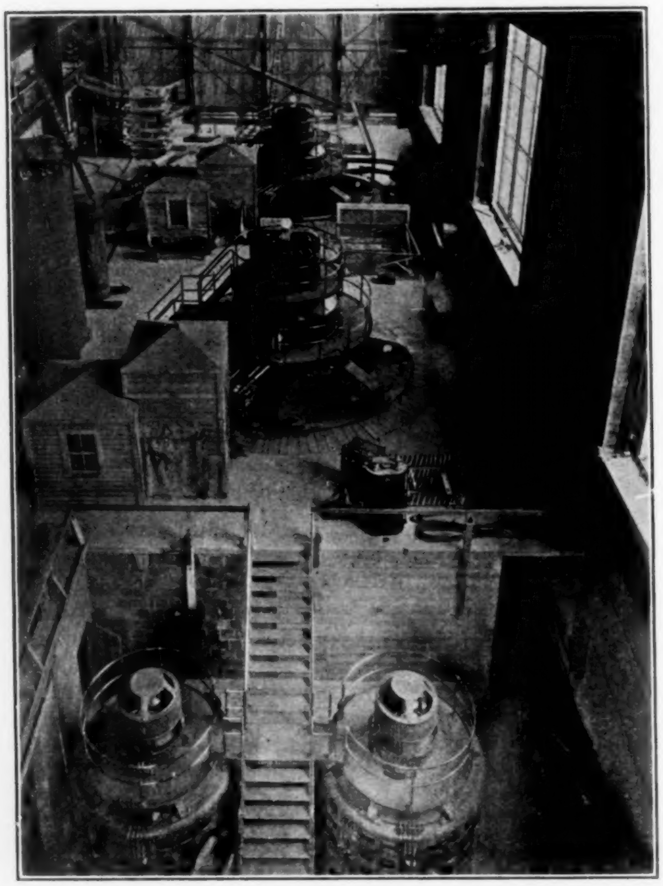


Fig. 6 Interior View of Generator Room

of the water-lubricated lignum vitae type, such as has been used on all modern vertical-turbine plants. This type of bearing has been selected on account of its simplicity and low maintenance cost.

The draft tubes are all of the Moody spreading type except that of No. 1, which is a bent tube.

On account of the limitations in the use of water at Niagara the runners are designed to obtain their maximum efficiency at a point about 10 per cent below their maximum rated output, at which load for the most part they are operated. This condition required that the runners be larger than would normally be used and that the turbines be "gated back." With the gates full open actual tests have shown that the capacity of Nos. 1 and 2 is 60,500 hp. each, and of Nos. 3, 4, and 5, 65,500 hp. each, under 305 ft. head.

Exhaustive tests have been carried out on the units, using the Gibson "pressure-time" method for determining the discharge. The maximum efficiency obtained on each turbine was 93 per cent, exceeding, so far as is known, any figure heretofore recorded on a commercial operating turbine. Fig. 5 shows a turbine casing erected in place.

The governor actuator is set on the generator floor, the flyballs being driven by belt from the turbine shaft. The main valve is located adjacent to the turbine regulating cylinders, 35 ft. below the actuator. To meet the conditions of this layout the pilot valve is hydraulically coupled to a small piston valve which is mechanically connected to the pilot valve of the main dog valve. The hand-control stand is located on the generator floor and operates the regulating cylinders through the governor pressure system.

The governors are operated on the "central" type of pressure system. Two motor-driven centrifugal pumps, each delivering 500 imp. gal. per min., and located adjacent to two 3000-gal. sump tanks built into the concrete substructure of the power house, deliver the governor fluid at a pressure of 200 lb. per sq. in. to a header from which branches are connected to the governors through individual pressure tanks. The capacity of one pump is sufficient to operate five governors.

The fluid used in the governor system is filtered water in which is dissolved, 7 lb. potassium bichromate to every 1000 gal. water. This fluid does not corrode the valve seats and has proved satisfactory in service.

Service Turbines. The two service-turbine casings have a 30-in. inlet diameter and runners of 42 in. outside diameter. The gate mechanism is of the "outside" type, similar to the main turbine.

The governor is the "direct-connected" type, and the pressure liquid is ordinary lubricating oil. The flyballs are mounted upon the main turbine shaft, and the governor stand with self-contained pumping unit is placed on the turbine floor.

A band brake is furnished in order to assist in bringing the unit to a quick stop when necessary.

Johnson Valves. A Johnson valve is located on each penstock near the entrance to the turbine casing. The action of this type of valve has been frequently described in other papers. The control of the Queenston valve is made through the operation of three small Johnson valves which automatically adjust the flow into the central and annular chambers so that the main valve plunger cannot travel at a dangerous rate. The closing stroke is cushioned at the end, and in the opening stroke the plunger moves just sufficiently to permit the wheel case to be primed before completing its stroke. An emergency handle is located on the control stand on the generator floor by which an operator can close the Johnson valve in case of trouble. The valve can be opened only from the control located adjacent to the valve itself.

Acres Control Pedestal. For the purpose of the floor operation of each unit, a pedestal is erected adjacent to each generator. On this pedestal are mounted the pressure and vacuum gages for the turbine, signal light and loud-talking telephone from the control room, temperature indicators from the generator windings, oil- and water-flow indicators, a control for the air brakes, and the emergency closing control for the Johnson valve. An operator standing at the pedestal is in close communication with the control room and at the same time has under his hand the control of the turbine governor and Johnson valve. The signal lights operated from the control room call the floor operator to any unit desired.

Generators. The present five units are each rated at 45,000 kva., 80 per cent power factor, 12,000 volts, three-phase, 25 cycles at 187.5 r.p.m. They are capable of being operated continuously at 49,500 kva. with either voltage or current 10 per cent in excess of the rated values. The type is vertical (see Fig. 6) with direct-connected, shunt-field, commutating-pole, 250-volt, 150-kw. exciter. The overall efficiency of the generating units is slightly in excess of 97 per cent at 80 per cent power factor. The thrust bearing is designed to support a load of one million pounds, which is slightly more than the weight of the rotor plus the hydraulic thrust imposed by the turbine. Upper and lower guide bearings are provided, the latter on account of the length of shaft and to keep the generator a self-contained unit.

The overall diameter of these units is 25 ft., the diameter of rotor over pole faces being 18 ft. approximately. The shafts are 30 in. in diameter in the guide bearings and are provided with a flange at the lower end for bolting to a corresponding one on turbine shaft. The shafts are hollow with an 8-in.-diameter bore and are 30 ft. 3 in. in total length. The overall height of the generators

above the generator floor is 26 ft. 10 in., thus above the main floor only the top of the frame and the upper bracket, thrust-bearing housing, and exciter are visible (Fig. 6).

The weight of the complete generator is 1,400,000 lb. and that of the rotor, 615,000 lb. The largest piece to be handled by the cranes weighs 600,000 lb.

It was specified that there should be a thrust bearing at the top to carry the weight of the rotating part and the total thrust due to turbine at rated speed and at overspeed; that the rotor be capable of operating at an overspeed of 347 r.p.m. without injury to any part; also that provision for easy handling of various parts be made.

Contracts were placed with two manufacturers who used different methods in constructing the generators, the general difference being that one made use of a built-up laminated sheet-steel rotor rim mounted on a small cast-steel spider; of cast iron in the upper and lower bearing brackets; and of a Kingsbury thrust bearing to carry the rotating parts; while the other used a rotor consisting of seven cast-steel wheels shrunk on to the shaft; cast steel in the upper and lower bearing brackets; and a thrust bearing with stationary bearing plate supported on a large number of small springs. Both manufacturers used forged-steel hollow shafts of approximately the same dimensions, which were 30 in. in diameter in the guide bearings and had a forged half-coupling at the lower end.

The steel forgings and steel and iron castings were required to meet the specifications of the American Society for Testing Materials. With reference to the steel castings, particularly those of large section such as are used in the cast-steel rotor wheels, attention is drawn to the advisability of not depending entirely on small test pieces attached to the casting to determine if the annealing has been properly carried out. It is the practice of the Commission on these large rotor castings to require that test pieces taken from 4-in. by 4-in. blocks 12 in. long cast on the outside and underside of the rim meet the specification requirements, also that core-drill samples be taken from the rim at the ends of the arms and if possible from between the arms, these samples being tested and examined to determine the quality of the metal.

The two types of bearings provided are interchangeable in the housings as constructed. In the Kingsbury bearing the shaft is supported on the thrust bearing by a nut threaded on the upper end of the shaft. The nut rests on a thrust collar which rests on the runner plate of the thrust bearing. The runner plate is of cast iron with a very highly finished surface, being true to 0.0002 in.

The stationary bearing surface consists of six babbitted sector-shaped shoes, each mounted on a support on the head of a jack screw so that it is free to tilt.

The maximum diameter of the runner plate is 69 in. The total area of the shoes is approximately 2500 sq. in., so that the unit pressure is 380 lb. per sq. in.

In running, a wedge of oil is dragged between each shoe and the runner plate, the shoe tilting sufficiently to accommodate this wedge, so that the rotor floats on a film of oil.

The friction losses in this bearing at normal load and speed are approximately 90 hp. Lubricating oil is circulated at the rate of about 4 gal. per min. between the purifying system and the bearing housing.

In the spring type of bearing the thrust is taken from the shaft to a cast-steel thrust collar by means of a shear key in a groove in the shaft. The groove is 3 in. wide and the shaft 29 in. in diameter. The thrust collar rests on a runner plate of cast iron 69 in. in diameter and is attached by two 2-in. dowel pins to prevent relative rotation. The carefully finished surface of the runner plate runs on a stationary steel ring with a babbitted surface, which in turn is supported on a nest of over 700 steel spiral springs. The babbitted ring is split in one place radially to give flexibility and the surface is radially grooved to allow oil to reach the rubbing surfaces. The unit pressure is about 265 lb. per sq. in. of bearing surface at 960,000 lb. total downward thrust. Total loss in the bearing is about 125 hp.

Growth in Demand for Hydroelectric Power

The first five units of the Queenston-Chippawa development are now in operation and the other units are being installed as rapidly as possible, and when completed the Commission will have a generating capacity for the Niagara District of over 900,000 hp., including the Toronto Power Co. and the Ontario Power plants.

Since 1910 the demand for "Hydro" service from the Commission has grown from an output of 750 hp., taken by 10 urban municipalities, to one of 628,000 hp. (of which 75,000 hp. is exported) taken by 250 municipalities and 97 townships supplying 335,000 consumers.

Realizing as it does the large amount of time—often several years—that must elapse between the initiation of a new, extensive water-power development and its being brought to the stage where commercial power can be delivered, the Hydro-Electric Power Commission has always been compelled to take early action on behalf of municipalities for the creation of new sources of supply for electrical energy. It has sometimes required a good deal of courage on the part of the officers of the Commission to incur heavy financial outlay years in advance of the actual demonstration of markets to absorb electrical output, but, in no instance, has its judgment eventually been found to have been in error.

At the present time, all evidence points to the fact that by the end of the year 1926 the existing provisions made for the supply of electrical energy to municipalities will be fully taxed and no spare power will be available. The output of the Queenston-Chippawa plant will have been absorbed. The Commission has considered the possibility of producing further power at Niagara Falls, but the chairman of the Commission, Sir Adam Beck, has stated from the public platform that he believes that it would be more profitable for all concerned to turn to the St. Lawrence River for the next large hydroelectric development.

Power on the St. Lawrence River

The province of Ontario shares with the state of New York the water power in the international stretch of the St. Lawrence River extending from Prescott to the international boundary. In this portion of the river there is a possibility of developing upon a conservative basis about 1,600,000 hp., of which 800,000 hp. would belong to Ontario. For several years the Commission has been conducting special surveys and investigations with the view of determining the best means of developing the international reach of the river in the joint interests of power and of navigation.

The International Joint Commission has had the problem of the most efficient development and utilization of the St. Lawrence river in the joint interests of navigation and power referred to it for report. The Commission reported about a year ago to the International Joint Commission in detail on the development of the St. Lawrence, but, so far as is known, the two governments interested—the United States and the Dominion of Canada—have announced no decision respecting the development.

This international stretch of the river is a feature which must be considered in its relationship to the larger project of dealing with the Great Lakes route to the sea. The necessity for additional power in Ontario is urgent; but this can be dealt with at once without making any improvements to the St. Lawrence River for navigation purposes, except in so far as they affect the power works contemplated.

Rates Charged for Electrical Energy

One of the basic principles upon which the Hydro-Electric Power Commission of Ontario operates is the furnishing of electrical energy to consumers *at cost*. Time and again, it has been stated that the rates for light and power resulting from the efforts of the Commission were much less favorable than those prevailing in other places. However, the author wishes to state that nowhere in the world over such extensive areas do communities and citizens obtain electric power and light at such low rates as prevail throughout the hydro municipalities in the province of Ontario, namely, from 1.5 to 3.1 cents per kw-hr. for residence and commercial service, and from $13.26 to $25.14 per hp-year for power service.

The secret of the phenomenal growth of the operations of the Commission lies in the fact that as the trustee and agent of coöperating municipalities it has made available to them electrical energy *at cost*, which they have then distributed and vended to their individual consumers at *as near cost as possible*. Moreover the Commission has made its distribution of energy to small municipalities and to rural districts, and the demand of these small municipalities aggregates a substantial load. Electrical energy, once a luxury, has now become a common commodity of the people.

Discussion on Papers on Hydroelectric Powers in Canada

The preceding papers, Power Development in the Province of Quebec, by Julian C. Smith, and Development of Hydroelectric Power in Ontario, by Frederick A. Gaby, were presented at the first power session of the Spring Meeting, held on Tuesday morning, May 29. Prof. A. G. Christie was presiding officer. Mr. Smith's paper was presented by P. S. Gregory, one of his associates.

F. Darlington,[1] who opened the discussion on these papers, gave emphasis to a statement by Mr. Gaby, pointing out that economic operations were rapidly extending the application of power and that it was most important that the supply should keep pace with the need. He referred to certain features of the power industry that were international in their scope, such as the increased centralization and unification of power service by interconnecting and expanding existing electric systems. This he characterized as the greatest forward step that could be taken to put cheap and dependable power within reach of all. He stated that it was not enough to have a huge power plant at Niagara Falls or on the St. Lawrence or in the Pennsylvania coal fields, for while power confined to these places might be used in factories or electrochemical works located at the source, its more general use and broader application must be through wide distribution to industrial and social needs. Only by wide distribution from the best natural power resources, could the public be properly served.

Of the two basic resources for power generation—fuel and water—one was conserved by saving it, the other was lost if it was not used; but where both were available the best conservation was achieved by using them to supplement each other. Then also, whichever source of power was used there must be great generating plants and power-transmission systems, and conservation required that the fullest possible use should be made of these structures.

All the conditions for conservation and high economy were enhanced by interconnections between electric systems to combine the loads into big blocks and permit the use at all times of the most economical available source of power; and when new generating plants were built always the most efficient source of power within the area of the interconnected system could be used, whether it was a water power or a steam plant at a coal mine, or at tidewater or elsewhere.

In this connection Mr. Darlington called to mind the idea sometimes erroneously held, that if any given electric company had the cheapest source of power within practical transmission distance, such a company would have little or nothing to gain by tying in with other less fortunately situated concerns. This, he said, was radically wrong, even from a purely selfish point of view, for the more economical a generating plant might be, the more important it was that the fullest possible use should be made of it, and interconnection in great superpower systems brought opportunities for the fullest use of the most efficient plants, with corresponding economy and conservation. For example, a superior coal-mine plant, say in Pennsylvania, would gain much by interconnection with a New England, New York, or New Jersey superpower system, or still more by interconnection with the St. Lawrence, for by such means it would secure a fuller use of its plant, and a relay or breakdown connection for use in case of emergency.

Mr. Darlington referred to a statement made by Mr. Smith that the powers of Quebec would be fully utilized in 29 years, urging conservation through the best utilization of both water power and steam power by coördination and interconnection with United States resources.

John R. Freeman,[2] paid a tribute to the foresight of the Canadian Water Power Branch in studying the water-power resources long in advance of demand and seeing that each was developed to the best of its possibilities. They had mapped everything out before it had any real commercial value and had surveys on record so that when there was development there should be no tendency to make use of the best and leave the rest. The work of the Water Power Branch of the Dominion Government, he said, was model for the whole world, and there had been little appreciation of the magnificent work that it had been doing for twenty years not only in surveying water-power sites but also in the actual building of storage reservoirs.

Mr. Freeman referred to his early days in water-power work, fifty years ago, when he was with the water-power company at Lawrence, Mass. At that time there were about seventy turbines in Lawrence for a total of about 15,000 hp., and it used to be said that the Merrimac River was the hardest-worked river in the world. Now a single one of the Chippawa turbines had a greater capacity than all those seventy turbines at Lawrence plus all the turbines then at Lowell and Manchester.

W. M. White,[3] thought the hydroelectric achievements in Ontario and Quebec as described by the speakers were a striking illustration of what the engineer could do in developing nature's resources. The reason why the American manufacturer could compete successfully in the markets of the world and yet pay higher wages than his foreign competitors was because each American workman had behind him more horsepower per man than his competitor's workman had. Since the cost varied directly as the amount of power expended in production, it naturally followed, by inevitable law of competition, that the workman who could direct the greatest amount of power would receive the greatest wage. He urged on the engineers that they recommend the development of power in any form.

Mr. Gregory[4] took up the question of interconnection of plants, interpreting Mr. Smith's statement that the electric steam generator was a necessary adjunct to all hydroelectric plants. This statement did not refer to a steam stand-by plant in connection with the hydro. It was not the custom, he said, to have steam stand-by plants, but as in all rivers in Canada the flow varied very greatly in different seasons, there were times in the year when water must be spilled over the dam, and it was in order to utilize this water that electric steam generators were being used and had been pushed to a high state of development. He mentioned as examples two electric steam generators in the plant of the Laurentide Company at Grand Mere which, united, had a capacity of 2500 kw., or 2500 steam b.hp., and also to a steam generator in the mill at Shawinigan having a capacity of about 3000 kw. or 3000 b.hp. The power that was used in these steam generator was surplus power which would otherwise spill over the dam. The interconnection which was made use of in Canada was interconnection of water-power plants on different rivers, on different watersheds where the periods of high water varied. For instance, if the plants which were now developed or would be developed on the Saguenay River could be connected with the plants developed on the St. Lawrence, there would result a far shorter period of low water because the high-water period on the Saguenay was from three weeks to a month or more behind the high-water period on the St. Lawrence. This would also apply to plants farther west which had their high-water period earlier than those on the St. Lawrence.

Mr. Gaby commented on Mr. Darlington's statement in regard to interconnection, mentioning illustrations of interconnection in the Ontario systems.

Mr. Freeman inquired as to the difference between steam-generated electricity and electricity generated by coal, that is, assuming coal to be worth an ordinary price of \$8 or \$10 a ton what did the companies get for their water power per year when they put it into steam boiler horsepower?

Mr. Gregory, in reply, said that one kilowatt-hour of electrical energy would produce about 3 lb. of steam at ordinary pressure, say 125 lb. per sq. in. There were 3412 B.t.u. in a kilowatt-hour. Taking the average of evaporation of $7^1/_2$ lb. of steam per pound of coal, which was a reasonable average, one ton of coal would produce 15,000 lb. of steam; therefore 5000 kw-hr. was the equivalent of one ton of coal, and if a ton of coal cost \$10, the 5000 kw-hr. would be worth two mills each. There were 6500 kw-hr. in one horsepower-year at 100 per cent load factor. At two mills each they would be worth \$13 per horsepower-year, and so on in that regular ratio.

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Effect of Feedwater Heating on Plant Economy

Studies of a Plant Equipped with 30,000-Kw. Units Which Clearly Indicate the Advantage of Bleeding the Main Turbine Both in Plants With and Without Economizers

By G. G. BELL,[1] PITTSBURGH, PA.

THE EFFECT of feedwater heating on plant economy is very interestingly discussed in a paper presented by Linn Helander[2] at the A.S.M.E. Annual Meeting, December, 1922. Mr. Helander has made a very complete study of the subject, and shows the theoretical relation between plants equipped with large and small house turbines, both with high boilers without economizers and medium-sized boilers with economizers.

In the spring of 1922 two more 30,000-kw. units were purchased for the Windsor station of the West Penn Power Co., Pittsburgh, Pa., the boiler-drum pressure was raised from 250 to 350 lb., and on account of this higher pressure steel-tube economizers were substituted for the cast-iron economizer which had been installed with the first 16 boilers in the plant.

The troubles which other plants had had with corrosion in steel-tube economizers necessitated the installation of deaërating apparatus. Manufacturers of deaërating apparatus claimed that air separation was easier at temperatures above 160 deg. fahr. Experience with a closed system of feedwater heating which prevented enrichment had maintained an average oxygen content in the feedwater above 0.25 cc. per liter, provided the feedwater temperature was maintained around 210 deg. fahr. Investigations of an existing plant equipped with economizers had indicated some advantages in increasing the feedwater temperature to 210 deg. fahr. by utilizing the exhaust steam from a house turbine of sufficient size

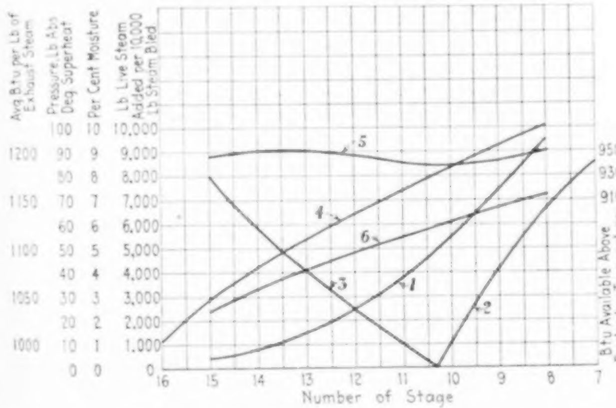

Fig. 1 Data on Steam Extracted from 30,000-kw. G. E. Curtis Turbine

(Steam condition, 300 lb., 200 deg., and 1 in. back pressure; load on turbine, 28,000 kw.
Curve 1—Absolute pressure at various stages
Curve 2—Deg. superheat in steam bled from the various stages
Curve 3—Percentage of moisture in bled steam
Curve 4—Average B.t.u. per lb. of bled steam
Curve 5—B.t.u. available for heating feedwater to maximum possible temperature by steam bled from any stage
Curve 6—No. of lb. of live steam that must be added to permit extraction of 10,000 lb. of steam at various bleeding points.)

to supply the auxiliaries with power; although subsequent investigations have demonstrated that probably there would be a slightly higher saving if the study had been made for a temperature of 190 deg. instead of 210 deg.

In the new addition it was decided to heat the condensate by steam bled from the main unit instead of exhaust steam from the house turbine, and it was thought that the best temperature at which the feedwater should enter the economizers should not be less than 210 deg. on account of the more efficient use of the steam in the main unit. To check this a study was made, as a result of which it was decided to heat the feedwater to the highest temperature possible by extracting steam from the thirteenth stage.

[1] West Penn Power Co., Pittsburgh, Pa.

[2] Feed Heating for High Thermal Efficiency, by Linn Helander, Trans. A.S.M.E., vol. 44; also (abridged) Mechanical Engineering, February, 1923, p. 105.

Upon the preparation of Mr. Helander's paper, these studies were revised. Additional data on the turbine were obtained so as to give complete information for bleeding all stages from the eighth to the fifteenth, inclusive, and the effect on the economy of the station of single-, double-, and triple-stage bleeding within these limits was studied.

Data on steam extracted from the 30,000-kw. G. E. Curtis turbine at a load of 28,000-kw., steam conditions at throttle 300 lb., 200 deg., and 1 in. back pressure, are shown in Fig. 1.

In determining the temperature to which the feedwater could be heated by each of the various stages, it was assumed that there was

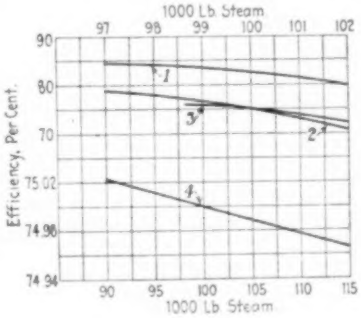

Fig. 2

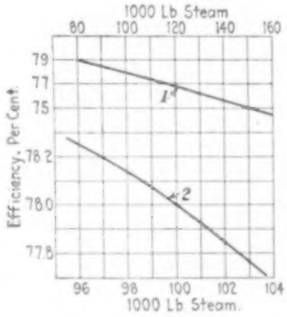

Fig. 3

Fig. 2 Efficiency of 14-High Cross-Drum B. & W. Boiler

(8341 sq. ft. of steel-tube economizer; steam pressure at drum, 325 lb.; temperature at superheater outlet, 225 deg. fahr.; feedwater temperature, 210 deg. fahr.)

Fig. 3 Efficiency of 20-High Cross-Drum B. & W. Boiler

(No economizer; steam pressure at drum, 325 lb.; temperature at superheater outlet, 225 deg.; feedwater temperature 210 deg.)

a loss between the turbine and the heater of 1 lb. when steam was extracted from the fifteenth stage, of $1^1/_2$ lb. when extracted from the fourteenth stage, and 2 lb. when extracted from the thirteenth or any higher stage; and that in all cases the maximum temperature to which the feedwater could be heated was 10 deg. lower than the temperature corresponding to the pressure of the steam at the heater.

The boilers purchased for Windsor are Babcock & Wilcox cross-drum boilers 14 tubes high and 42 tubes wide, and are equipped with a slag screen and Babcock & Wilcox inclined baffle. The front headers are set 21 ft. above the floor, the drum center being 35 ft. 3 in. Four boilers are provided per unit, although it was assumed that when the turbine was operating at its point of best efficiency, which is 28,000 kw., three boilers would supply steam for the unit, the output of each boiler being about 100,000 lb. when feedwater is supplied at a temperature of 210 deg.

The extra boiler capacity would be utilized in reducing the rating on the boilers in the older section of the plant, which are not as efficient or as liberally stokered as the newer boilers.

Fig. 2 shows the efficiency of the new boiler and steel-tube economizer at various ratings. Curve 1 shows the combined efficiency of boiler and economizer; curve 2 the efficiency of the boiler alone, and curve 3 the boiler efficiency corrected for the effect of change in capacity on the efficiency of the economizer. Curve 4 is that portion of curve 3 which is used, amplified so as to permit of reading any slight variation in the relative efficiency of the boiler when operating at slight differences in output.

These figures are based upon 12 per cent CO_2. It is necessary in order to compare the results of bleeding from various stages to work to a fraction of one per cent. All computations were checked by the comptometer.

Fig. 3 presents similar data for a 20-tube-high boiler without economizers. Curve 1 gives the efficiency of the boiler at various ratings, while curve 2 is that portion of curve 1 which is used, amplified so as to permit of reading any slight variation in the relative

efficiency of the boiler when operating at slight differences in output.

In connection with the 14-tube-high boiler, 8341-sq.-ft. steel economizers are installed. Table 1 gives the rise in the economizers when operating at a constant output of 100,000 lb. of steam per hour with feedwater temperatures of 135, 170, 210, and 250 deg.

TABLE 1 TEMPERATURE RISE IN ECONOMIZERS WHEN OPERATING AT A CONSTANT OUTPUT OF 100,000 LB. OF STEAM PER HOUR WITH VARIOUS FEEDWATER TEMPERATURES

	Feedwater temperatures, deg. fahr.			
	135	170	210	250
Gas temperature entering economizers, deg. fahr	595	595	595	595
Gas temperature out of economizers, deg. fahr	297	319	345	370
Drop in economizers, deg. fahr	298	276	250	225
Average gas temperature, deg. fahr	446	457	470	482.5
Water inlet to economizers, deg. fahr	135	170	210	250
Estimated rise in economizers, deg. fahr	128	118	107	96
Temperature of water leaving economizers, deg. fahr.	263	288	317	346
Average water temperature, deg. fahr	199	229	263.5	298
Average thermal difference in economizers, deg. fahr.	247	228	206.5	184.5
Rise in economizers, deg. fahr	128	118.4	107	95.8

The figures are derived from guarantees based on 210-deg. feedwater and are proportional to the arithmetical mean of the temperature differences.

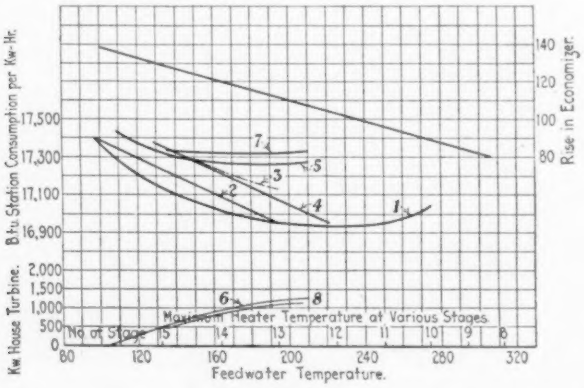

Fig. 4 Comparison of Effect on Station Economy of Heating Feedwater by Exhaust Steam from House Turbine, Efficient Duplex-Driven Auxiliaries and Single-Stage-Extraction Heating

(North extension of Windsor power station. 30,000-kw. G. E. turbines, 28,000-kw. load; 14-high cross-drum B. & W. boilers; induced draft; 60 per cent economizer; steam conditions at throttle, 300 lb., 200 deg., 1 in. back pressure.)

These results are plotted in Fig. 4, which also shows a comparison of single-extraction heating and heating the condensate by exhaust steam from a house turbine if the Windsor plant is equipped with a 14-tube-high boiler and 8341-sq.-ft. economizers.

Curve 1 shows the heat consumption of the plant if the turbine is arranged for single-stage bleeding. These results are arrived at by calculating the heat requirements with bleeding at various stages from the tenth to the fifteenth, and drawing a curve through the points thus obtained. The curve represents the results which might be obtained if the turbine were designed with an infinite number of stages and could be bled at any one of them. As a matter of practice these results can only be obtained when steam is bled from any one of the six stages coming within the limit of this curve and the feedwater is heated as hot as possible by the steam extracted from the tubine.

Curve 2 shows the effect of bleeding from the thirteenth stage and throttling the amount of steam bled so as to get a varying temperature. This is practically a straight line. For the purpose of this study the condensate was assumed to be heated first approximately 20 deg. by the heat contained in the steam escaping from the steam seal. Twenty degrees is also the amount the condensate would be heated if before passing into the first bleeder heater it first cooled the generator air and then absorbed the heat in the bearing and transformer oil for the unit.

On curves 1 and 2 it was assumed that the boiler-feed pump was motor-driven. If in place of a motor-driven boiler-feed pump a steam-driven pump is used, curve 3 will represent the heat requirements of the station. When sufficient steam is bled from the main unit to heat the feedwater to the maximum obtainable from the thirteenth stage, the heat consumption in the plant equipped with a motor-driven pump is approximately 1 per cent less than in one provided with a steam-turbine-driven pump. This is when the exhaust steam from the steam-driven boiler-feed pump is discharged into the same heater as the steam bled from the main unit. When using a steam-driven boiler-feed pump the minimum temperature increased from 97.5 to 127.5 deg. fahr.

Curve 4 shows the results if steam from the boiler-feed pump is discharged to a separate heater and used to heat the feedwater sufficiently above the temperature of the feedwater leaving the extraction heater to get the necessary reëvaporation to permit the deaërator to function satisfactorily. Where the pressure will permit, the exhaust steam from the turbine glands is discharged into the same condenser as the exhaust steam from the boiler-feed pump. The curve indicates that approximately the same results can be obtained by using the turbine-driven pump as with the motor-driven pump, provided that separate heaters are used and the feedwater is heated approximately 25 deg. above that used with a motor-driven-boiler-feed pump.

Curve 5 shows the results which would be obtained if the feedwater were heated by exhaust steam from a house turbine. Guarantees were obtained on house turbines designed for three different back pressures, and in figuring this curve the steam consumption used in each case would apply only if a special house turbine were designed for the operating conditions under consideration. This curve indicates that there is very little difference in the economy of using a house turbine in connection with the 14-tube-high boiler and 60 per cent economizer with feedwater temperatures between 170 and 190 deg. Assuming that this house turbine had been bought for a back pressure corresponding to 180 deg., if the feedwater temperature were then varied by increasing or decreasing the output from the house turbine, the heat requirements of the plant over the range would be higher than shown in curve 5, and would only coincide with that curve when using a feedwater temperature of 180 deg., the point for which this particular turbine was designed.

Curve 6 shows the amount of power which can be obtained from the house turbines when heating the feedwater to the temperatures shown in curve 5.

Curve 7 shows the reults which would be obtained if the feedwater were heated by exhaust steam from efficient high-speed geared turbines driving the auxiliaries. In this case one design of turbine is used and operated with various back pressures, so that full advantage is not taken of the increase in vacuum which it is possible to get with the lower feedwater temperature. The water rate for various feedwater temperatures is given in Table 2.

TABLE 2 WATER RATE FOR VARIOUS FEEDWATER TEMPERATURES

Final feedwater temperature, deg. fahr.	Back pressure on turbine exhaust, lb. per sq. in.	Water rate, lb. per brake hp-hr.
135	4.53	16.5
170	7.99	17.0
210	16.13	21.0

The curve indicates that within the range of the temperatures under consideration there is practically no difference in the heat requirements of the plant, although if the small geared sets were so designed as to show an increase in economy with a decrease in back pressure, it would pay to lower the feedwater temperature to the lowest point that was practicable and still prevent the sweating of the economizer tubes.

Curve 8 shows the amount of power generated by the geared-turbine-driven sets. The reason that curves 5 and 7 approach each other at the lower temperatures is that the house turbine is of larger capacity and at low feedwater temperatures is operated at part loads, whereas in curve 7 it is assumed that only enough of the gear-driven units are run to give the required temperature when each turbine is carrying the maximum load.

Fig. 5 shows a comparison of results on the Windsor plant if the turbine were arranged for single-, double-, or triple-stage extraction heating and the plant equipped with 14-tube-high boilers and 8341-sq.-ft. economizers.

Curve 1 shows the heat consumption of a plant arranged for single-stage bleeding at any of the temperatures within the limits of the curve. This curve is the same as curve 1 of Fig. 4 and shows best results at a feedwater temperature of 225 deg. fahr., with a very slight increase in heat requirements by increasing or decreasing the feedwater temperature 25 or 30 deg.

Curve 2 shows the heat consumption of a plant arranged for bleeding from the fourteenth and a higher stage.

Curve 3 shows the heat consumption when bleeding from the thirteenth stage and a higher stage.

Curve 2 shows that minimum heat requirements are obtained by a combination of the fourteenth and twelfth or eleventh stages at a temperature of 225 or 251 deg. fahr.

Curve 4 shows that the best results with triple-stage heating are obtained with a combination of the fourteenth, twelfth, and tenth stages, the best results being obtained at a temperature of 275 deg. fahr.

Curve 5 shows the heat consumption with triple-stage heating using the fourteenth, eleventh, and a higher stage. This combination is not as efficient as that shown in curve 4.

These studies are all made for a plant operated with a motor-driven boiler-feed pump. They indicate that there is very little difference between bleeding the eleventh, twelfth, or the thirteenth stage with single-stage heating; and that for double-stage heating a combination of the fourteenth and twelfth or eleventh stages gives the best result, the heat requirements per net kw-hr. being about 16,750 as against 16,940 B.t.u. for single-stage heating. In triple-stage heating a combination of the fourteenth, twelfth, and tenth stages gives the best results, the heat requirements for triple-stage bleeding being about 16,600 B.t.u. as compared with 16,750 B.t.u. for the double-stage heating and 16,940 B.t.u. for single-stage heating.

While there are a number of points to consider in obtaining plant requirements, the work can be reduced to a comparatively simple form; and with a set of curves such as those in Fig. 1 which give information for various stages and temperatures, etc., a point can be determined every twenty minutes by using a slide rule. However, a slide rule is not accurate enough to give smooth curves.

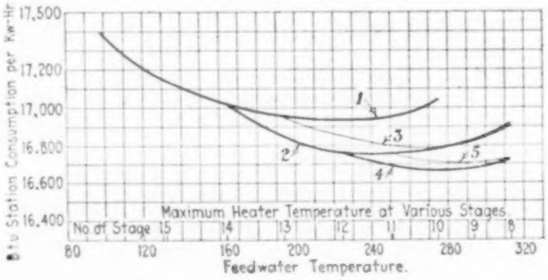

FIG. 5 EFFECT OF SINGLE-, DOUBLE-, AND TRIPLE-STAGE EXTRACTION HEATING ON FEEDWATER TEMPERATURE AND STATION ECONOMY

(North extension of Windsor power station. 30,000-kw. G. E. turbines, 28,000-kw. load; Steam conditions at throttle: 300 lb., 200 deg., and 1 in. back pressure. 14-high cross-drum B. & W. boiler; 60 per cent economizer; induced draft.)

In order to illustrate the method used in making these computations the formulas employed are given below, the following notation being adopted.

- A = pounds of steam required by main turbine to produce 28,000 kw. per hour when no steam is extracted from turbine
- X = thousands of pounds of steam bled from main unit to heat the feedwater in the first-stage heater
- Y = thousands of pounds of steam bled from main unit to heat the feedwater in the second-stage heater
- Z = thousands of pounds of steam bled from main unit to heat the feedwater in the third-stage heater
- r_x = pounds of steam which have to be added per thousand pounds extracted from the x-stage
- T_c = temperature in deg. fahr. of condensate leaving main condenser
- T_x = temperature of condensate leaving a heater supplied with steam from the x-stage
- B = pounds of steam entering condenser
- C = B.t.u. by test in the amount of steam required for sealing the high-pressure gland of main unit. This is a constant and is 5,500,000 B.t.u. above the liquid temperature of 78 deg. Where it is desired to use the number of B.t.u. in the gland steam above 32 deg., a figure of 5,700,000 is used
- D = total pounds of live steam to be supplied to turbine
- E = net kw-hr. put out by plant
- H_x = average total heat in steam bled from main unit at the x-stage
- F = equivalent pounds of steam that each boiler would evaporate if supplied with feedwater entering the 20-high boiler (or the economizer in case boiler is equipped with economizer) at 210 deg. fahr.
- H_s = total heat in steam leaving superheater
- h_x = heat in the condensate above 32 deg. after being heated by the steam bled from the main turbine at the x-stage
- R = rise in economizer after condensate has been heated by steam extracted from the one or more stages of the main unit
- R_{210} = rise in economizer when condensate enters economizer at a temperature of 210 deg.
- B_e = boiler efficiency
- P_e = ratio between results which we expect to get in ordinary operation as compared with the results which might be expected from manufacturer's guarantees. This ratio includes the plant losses from condensation, steam leaks, soot-blower loss, radiation from steam pipes, etc.
- G = total steam output of boilers in operation supplying each unit. In this study each boiler was assumed to have an efficiency of 75 per cent when the boiler and economizer together were supplying 100,000 lb. of steam per hour or 78 per cent when steam was supplied by a 20-high boiler operating at the same output.

Total live steam to turbine = $A + Xr_x + Yr_y + Zr_z$

Amount of steam to be bled by first-stage heater:

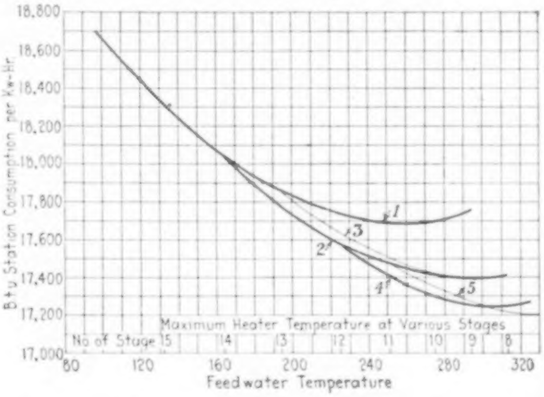

FIG. 6 EFFECT OF SINGLE-, DOUBLE-, AND TRIPLE-STAGE EXTRACTION HEATING ON FEEDWATER TEMPERATURE AND STATION ECONOMY

(North extention of Windsor power station. 30,000-kw. G. E. turbines, 28,000-kw. load. Steam conditions at throttle: 300 lb., 200 deg., and 1 in. back pressure. 20-high cross-drum B. & W. boilers; no economizer; natural draft.)

$$X = \frac{(A - X - Y - Z + Xr_x + Yr_y + Zr_z)(T_x - T_c) - C}{H_x - h_x}$$

Amount of steam to be bled by second-stage heater:

$$Y = \frac{(A - Y - Z + Xr_x + Yr_y + Zr_z)(T_y - T_x)}{H_y - h_y}$$

Amount of steam to be bled by third-stage heater:

$$Z = \frac{(A - Z + Xr_x + Yr_y + Zr_z)(T_z - T_y)}{H_z - h_z}$$

To find the relation between X and Y, by changing the form of the equations we get

$$\frac{X(H_x - h_x) + C}{T_x - T_c} = A - X - Y - Z + Xr_x + Yr_y + Zr_z$$

$$\frac{Y(H_y - h_y)}{T_y - T_x} = A - Y - Z + Xr_x + Yr_p + Zr_z$$

Subtracting,

$$Y = \left[X + \frac{X(H_x - h_x) + C}{T_x - T_c}\right]\left(\frac{T_y - T_x}{H_y - h_y}\right)$$

All the quantities in the above equation are known except X and Y, so that a definite relation can be established between them.

Similarly, by combining the expressions for Y and Z the relation between them will be found to be

$$Z = Y\left[1 + \frac{H_y - h_y}{T_y - T_x}\right]\frac{T_z - T_y}{H_z - h_z}$$

Substituting the known values for a combination of the fourteenth, eleventh, and eighth stages we find that these equations when solved give simple answers.

$$Z = 0.771Y$$
$$Y = 1.110X + 5915$$
$$Z = 0.771Y = 855X + 4550$$

Substituting these values of Y and Z in the equation for X permits us to find X, and as the relations of X to Y and Z are known

we can then readily find the amount of steam bled at each stage; and multiplying this by the ratio of the amount of live steam that has to be added per 1000 lb. bled we can find readily the total steam supplied to the turbine, as follows:

$$D = A + Xr_x + Yr_y + Zr_z$$

The steam passing to the condenser is

$$B = (D - X - Y - Z)$$

There are two variables in considering the boiler rating; one is the number of pounds of steam to be evaporated, and the other is the number of B.t.u. to be added, which varies on account of varying feedwater temperature. When the economizer was supplied with 210-deg. feedwater each of the three 14-high boilers and economizers was assumed to be producing 100,000 lb. of steam or a total of 300,000 lb., the efficiency of the boilers alone was taken as 75 per cent (see Fig. 2), and the boiler efficiency under all other conditions was determined from this by correcting for changes in efficiency due to changed output and taking into account the effect of variation in feed temperature.

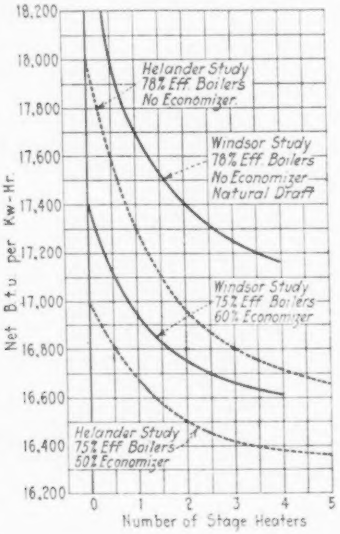

Fig. 7 Comparison of Windsor and Helander Studies of Effect of Various-Stage Bleeding on Power-Station Economy

If F = output of each boiler in pounds of steam per hour referred to 210-deg. feed temperature as a basis,

$$F = 100{,}000 \times \frac{H_z - h_z - R_z}{H_{210} - h_{210} - R_{210}} \times \frac{D}{300{,}000}$$

Fig. 2 gives the efficiency of the 14-tube-high boiler.

The net B.t.u. per kw-hr. output of the plant is obtained from the formula:

$$D \times \frac{H_z - h_z - R_z}{E} \times \frac{1}{B_e} \times \frac{1}{P_e}$$

where E is equal to the net kw-hr. put out by the plant.

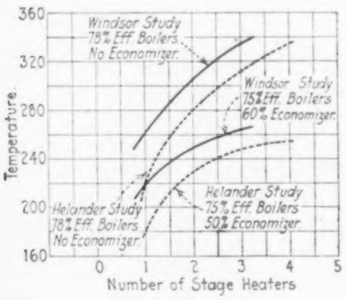

Fig. 8 Comparison of Windsor and Helander Studies Showing the Temperature at Which Best Results are Obtained for Various-Stage Bleeding

Where the plant was equipped with economizers and induced-draft fan, and a motor-driven boiler-feed pump was used, the plant-auxiliary power requirements were assumed to be 1600 kw. and E was equal to 28,000 — 1600 or 26,400 kw-hr. Where a turbine-driven boiler-feed pump was used, the plant-auxiliary power requirements were assumed to be 1400 kw. and E was equal to 28,000 − 1400 or 26,600 kw-hr.

In case the large boiler is used without the economizer, the rise in the economizer is neglected in the last two equations, and the boiler efficiency is taken from Fig. 3 instead of Fig. 2.

Where the high boiler is used with natural draft the boiler feed-pump requirements are reduced from 200 to 175 kw. and the auxiliary power is reduced 150 kw., on account of the omission of the induced-draft fan.

In case the steam-turbine-driven pumps are operated, Item C is increased by the amount of heat in the exhaust steam. In arriving at the B.t.u. in the exhaust steam, allowance was made for variations in back pressure by increasing the water rates of this unit $^1/_2$ per cent per pound increase of back pressure.

A great many of the above factors are constant, and only a few change so that when one is familiar with the method the points on the curves can be obtained at the rate of two or three per hour.

Fig. 6 is a study of single-, double-, and triple-stage heating for the Windsor turbines, in combination with a 20-tube-high boiler having an efficiency of about 78 per cent at the point at which it is operated.

Curve 1 shows the results obtained with single-stage bleeding.

Curves 2 and 3 show the results obtained with double-stage heating. There is apparently very little difference whether the thirteenth or fourteenth stage is used as the first stage.

Curve 5 shows the results obtained with triple-stage heating, the best being those obtained by a combination of the fourteenth, eleventh, and eighth stages. It is possible that a higher stage might be slightly more efficient, but the data therefore were not available.

Fig. 7 is a comparison of the results obtained by Mr. Helander for various-stage bleeding with the results of the Windsor study. Mr. Helander limited his study to four stages, but the curve is projected so as to show the approximate results for five stages. The Windsor study was made for three stages, but is extended so as to indicate the approximate results for four stages.

Fig. 8 shows the temperature at which the best results were obtained for single-, double-, and triple-stage bleeding in the Winsor study and single-, double, and quadruple-stage bleeding in the Helander study.

These studies clearly indicate the advantage of bleeding the main unit with or without economizers, there being a gain of 1.10 per cent for double-stage over single-stage heating and approximately one half that amount if triple-stage is used in place of double-stage heating, that is, for a 14-tube-high boiler equipped with economizer; whereas for a 20-tube-high boiler there is a gain of 1.64 per cent in

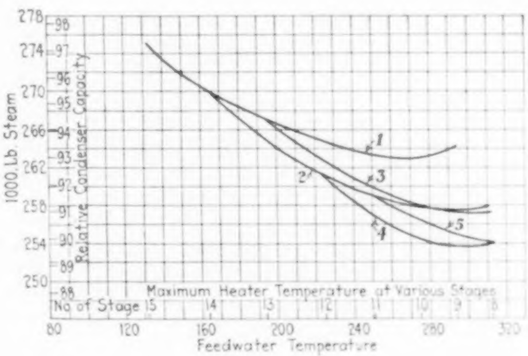

Fig. 9 Amount of Steam Passing to Main Condenser and Relative Size of Main Condenser Required

double-stage heating over single-stage, and about 1.00 per cent if triple-stage heating is used in place of double-stage.

Regarding reliability, while the heater condensers will complicate the condensate piping and increase the pumping head, with the possible exception of the effect of breakage of extraction heater tubes, it is difficult to see how they will affect the reliability of the plant or complicate the operating problems. The breakage of a condenser tube can be taken care of either by installing check valves between the heater and the main unit, or in the lower-stage heaters by putting in drip lines of large enough capacity to take care of possible leakage. Condensate that leaks through a broken tube in this way is returned to the condenser or condensate system, and is not lost. Gate valves should be installed between the heater and the main unit so that the heater can be disconnected from the unit if desired.

Regarding the capacity of condensing equipment, as the bleeding of the main unit reduces the amount of heat passing to the main condenser, some reduction in its size is permissible. Fig. 9 shows the pounds of vapor and condensed steam entering the main condenser per hour for various bleeding combinations. This study indicates that for single-stage bleeding the condenser capacity need only be 93 per cent of that required if steam is bled from the main unit. For double-stage heating this ratio becomes 91 per cent and for triple-stage heating 90 per cent.

Fig. 4 indicates that heating the feedwater by exhaust steam

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Diesel-Engine Progress on the Pacific Coast

By H. W. Crozier, John Stigen, and C. E. Nagel, San Francisco, Cal.

Diesel designers and builders on the Pacific Coast have been making important strides in the development of the full Diesel engine, particularly since they have resolutely turned from the so-called semi-Diesel engine, dependent for ignition of the fuel on a hot surface, and have concentrated their efforts on the true Diesel type, which uses only the heat of compression for that purpose. The bravery of these men in departing from European precedents in simplifying and strengthening the designs of their engines and their daring in using thousands of pounds pressure in attaining a solution of the mechanical solid-injection problem have resulted in the construction of splendidly satisfactory engines, a feat of which the profession may well be proud.

As an indication of the quality of the engines produced, practically all manufacturers fit forced-feed lubrication through drilled holes in crankshafts and drilled holes through connecting rods, insuring ample lubrication of the bearings, with resulting long life. Cylinder lubrication has careful attention and individual feed lines running to each cylinder from McCord-type force-feed lubricators are practically universal. No dependence is placed on splash, as forced feed is fitted to camshafts, timing gears, and other similar parts. Circulating pumps are nearly always direct-connected and in duplicate, and the prevalence of the marine demand necessitates use of brass and other high-grade metals suitable for salt-water service.

Favorable to the extended use of Diesel engines is the ample supply of suitable fuel, assured for many years to come, and an informed public accustomed to the extensive use of carburetor-type internal-combustion engines. True Diesel engines are being manufactured in increasing quantities and are being introduced for practically every mechanical purpose. Marine service has taken by far the largest proportion of the production, but stationary service is not neglected by any means. The whole range, from the smallest to the largest, and of good quality, is obtainable from one or more of the six or eight prominent manufacturers. In adaptability to new uses the Pacific Coast is leading along certain lines, particularly in the use of small and moderate-sized engines in heavy-duty marine service.

A Large Stationary Diesel-Electric Generating Set[1]

The recent shipment from Oakland, Cal., of a large stationary Diesel engine marks a forward step in California Diesel practice as it is the largest engine so far supplied for electric service.

This Diesel-electric unit consists of a six-cylinder, four-stroke-cycle, $20^1/_2$-in. by $35^1/_2$-in., 150-r.p.m., Pacific Werkspoor Diesel engine, direct-connected to a 925-kva., three-phase, 60-cycle, 2400-volt, Westinghouse alternating-current generator, with direct-connected exciter, and goes to the electric central station of the Tucson (Ariz.) Gas, Electric Light, and Power Company for installation as the fifth Diesel-electric unit.

It will run in parallel with four 500-b.hp. Diesel-electric units, each having direct-connected alternating-current generators and with 870 kw. of Corliss non-condensing steam-driven equipment used for standby and to assist over the peaks.

Of the crosshead type, so called, which has been so successful in the large sizes at sea, the new engine is materially different and much simpler than the four operating units at present in operation, which are all of the conventional trunk-piston type. Complete separation of the cylinder and engine lubricating systems and elimination of the oil contamination by discharges from the cylinders; simple and efficient piston cooling piping; ease of inspection of all operating parts while running, and ease with which pistons and piston rings may be inspected or removed, are some of the advantages of the crosshead type.

One of the important features of the design is the accessibility of the piston and piston rings. The cylinder is in two parts. The upper part includes practically all of the cylinder exposed to the hot gases; the lower part or skirt, mates with the upper in a stepped ground joint. With the piston on the lower dead center, removal of eight bolts permits lowering of the skirt, thereby exposing the piston and rings, for inspection or removal of rings. If the bolts holding the piston have been previously taken out, the piston may be removed from the engine in its entirety; all this of course without dismantling any other part of the engine.

Tucson has a high-grade circulating-water cooling system in service, which has been extended to supply the new engine. Its particular feature is the use of clean or distilled water in a closed circuit consisting of the engine jackets, heat-exchanger coils placed in the cooling towers, and a motor-driven circulating pump (in duplicate). The object attained is the prevention of scale on the cylinder cooling surfaces.

This engine was given a 24-hour full-load continuous test by the builders and the following performance data were obtained, the power being measured by a hydraulic brake:

Average output		562 kw. or 847 b.hp.
Indicated power of all 6 cylinders		1185 i.hp.
Average mean effective pressure		96 lb. persq. in.
Compressor:		
Low-pressure cylinder (15 lb. m.e.p.)	17 i.hp.	
Int.-pressure cylinder (57 lb. m.e.p.)	16 i.hp.	
High-pressure cylinder (386 lb. m.e.p.)	16 i.hp.	49 i.hp.
(Compressor i.hp. = 4.2 per cent of main engine i.hp.)		
Average fuel consumption		0.43 lb. per b.hp-hr.

For the moderate-sized units a station duty of 0.72 lb. per kw-hr. generated may be expected, corresponding to 0.47 lb. per b.hp-hr. Larger sizes comparable to the new engine may be expected to have a station duty of 0.67 lb. per kw-hr. or 0.445 lb. per b.hp-hr.

Lubricating oil will be required at the rate of about 1375 kw-hr. per gal. for trunk-type engines, but the larger engines, particularly of the crosshead type, have a higher lubricating oil economy and may reach 2000 kw-hr. per gal. if intelligently operated.

Pacific Coast Experience with Large Diesel-Engined Motorships[1]

It is but natural that the many advantages claimed for the Diesel engine should attract the attention of both the engineers and business men who have the present as well as the future welfare of the shipping industry in their charge. For marine work this type of motive power seems particularly adapted, especially in cases where the total horsepower required is not excessive. The simplest and most reliable arrangement for a marine steam power plant appears to be the Scotch marine boiler with marine superheaters and the triple- or quadruple-expansion engine, with which a total fuel-oil consumption of 1.25 to 1.40 lb. per shaft hp. is a fair average for up-to-date plants. When, then, the Diesel-engine advocate comes along claiming a fuel-oil consumption of from 0.38 to 0.45 lb. per shaft hp., it is no wonder that the man who holds the destiny of so vital an industry as our merchant marine should take notice. Besides this great fuel economy, the advantage of which increases with the increase in length of voyage, there are other features of the Diesel engine which prove a decided advantage when applied to a marine power plant. Among these are the instantaneous availability of full power at a moment's notice, without any special preparation; quick reversal from full speed ahead to full speed astern; immediate shutdown of engine in cases of emergency; a greater number of operating days per year, due to avoided delay in boiler cleaning and annual inspection; an increase in cargo capacity, due to reduced bunker oil required; and a reduction in the number of the crew, as no firemen are required. Against these advantages must be charged the disadvantages of a higher first cost, with the attendant increase in depreciation and insurance, a higher lubricating-oil consumption, and a smaller

Presented at the Pacific Coast Regional Meeting of The American Society of Mechanical Engineers, Los Angeles, Cal., April 16 to 18, 1923. Abridged.

[1] By H. W. Crozier, who also prepared the preceding introduction and the remaining portions of the paper not otherwise credited. Mr. Crozier is engineer with Sanderson & Porter, San Francisco, and a member of the A.S.M.E.

[1] By John Stigen, naval architect, Standard Oil Co. of California.

field from which to select the men to care for the plant. In view of these facts it is rather surprising that there are not more Diesel-engined motorships in the American merchant marine.

On the Pacific Coast the Standard Oil Company (Cal.), with which the writer has the privilege of being connected, has taken a leading part in introducing this type of motive power in the marine service.

In November, 1920, this company put in commission its first motorship, the *Charlie Watson*, a tanker of about 2135 dead-weight tons, propelled by two 550-b.hp. Pacific Werkspoor Diesel engines. A year later, a second motorship, the *H. T. Harper*, a tanker of 4700 deadweight tons equipped with two 850-b.hp. engines of the same make, was added. This vessel, as far as principal dimensions and lines of hull are concerned, is an exact duplicate of the Company's *El Segundo*, which has two Scotch marine boilers and a triple-expansion engine developing 1850 i.hp.

The fact that after two years' continuous operation of its Diesel-engined ships this company in July, 1922, placed an order for a third vessel with Diesel power should be sufficient proof that they regard their motorship enterprise as a success. This last vessel, which is now being completed, is a Diesel-electric tanker of about 1875 d.w. tons, equipped with two 400-b.hp. Pacific Werkspoor Diesel engines connected to direct-current generators which in turn supply power for a 600-b.hp. motor coupled direct to the propeller shaft. The vessel is designed for bay and harbor service as well as coastwise, and the Diesel-electric type of propulsion with direct pilot-house control was selected as particularly well adapted for this kind of work where a great deal of maneuvering has to be done.

The question of machinery weights is often quoted as being against the Diesel engine. This may or may not be correct, depending on the engines themselves, and also upon how much and what kind of auxiliaries are selected. With all capacity requirements equal the machinery weights of a motorship will approximate very closely those of a steamer, and should never exceed them by more than 10 per cent. This increase in machinery weights, however, is more than offset by the reduction in fuel oil required for any given length of voyage.

Basing our figures on the total fuel oil consumed for all purposes and the shaft horsepower developed, the fuel consumption per shaft horsepower per hour will be 1.35 lb. for the steamer *El Segundo* and 0.475 lb. for the motorship *H. T. Harper*. A correction must be made here to take care of the increase in the horsepower required due to reduced propulsive efficiency of the twin-screw installation of the motorship, which will bring the fuel consumption to 0.51 lb. per hp-hr.

This shows a decided advantage for the Diesel engine for propulsion, but in comparing the port consumption which takes in power used for discharging the oil cargo as well as for all other purposes, we find that the motorship, with its electric auxiliaries, performs this work with a fuel consumption of from 15 to 20 per cent of that required by the steamer.

Diesel-Electric Ferry, San Francisco Bay

San Francisco Bay has been noted for the high-class ferry service given with the fast, clean, and commodious ferry boats plying its waters. These are of the double-ended, two-deck type and are, with the exception of the new Diesel-electric ferry, *Golden Gate*, propelled by steam, several types of steam propelling machinery being used.

Diesel engineers attacking the problem of the San Francisco Bay ferries were astonished to find that the old walking-beam, low-pressure, jet condensing engines, noted as they are for their reliability and maneuvering qualities, are at the same time the most economical on the bay.

On the $4^1/_2$-mile route between Hyde street, San Francisco, and Sausalito, service is given with the Diesel-electric ferry running 16 hours and the steam ferry running 12 hours daily, the fuel consumptions being 5 gallons and 14 gallons per mile, respectively. Under construction at Los Angeles are two new steam turbine-electric ferries with double-end propellers which are expected to have the good economy for steam of about 30 gallons per mile. A Diesel-electric installation in this size ferry would use around 14 gallons per mile.

The Diesel-electric ferry *Golden Gate* has been running long enough for her merits to be recognized. She is particularly good in manoeuvering ability, accelerates rapidly, and on the whole is an exceedingly economical and profitable investment.

Her machinery consists of two Pacific Werkspoor Diesel engines, each direct-connected to 360-kw. 250-volt direct-current generators with direct-connected exciters which furnish current to drive the 500-volt propeller motors each of 750 b.hp. Kingsbury thrust bearings are fitted. The after propeller does most of the work of propelling the boat, and the leading one is controlled to operate at reduced speed and practically idles, consuming from 10 to 15 per cent of the power. This arrangement results in good economy because it is possible to design the propellers for the best operating conditions.

The ferry is usually operated directly from the pilot house. It may be thrown over from full speed ahead to full speed astern while under way, and the machinery responds immediately.

The combination of the electric drive with the advantages of speed control to get high propeller efficiency and the Diesel engine with its high fuel economy and reliability makes an excellent arrangement, and it is expected that many more Diesel-electric boats will be built. A second ferry, the *Golden West*, is nearly ready for its trial trip.

The 18,000 B.Hp. of Diesel Engines Built in Oakland, Cal.[1]

An important impulse was given to the Diesel industry on the Pacific Coast by the United States Shipping Board Emergency Fleet Corporation in awarding a contract for twenty 850-b.hp. Diesel marine engines to be built on San Francisco Bay, later reduced to 10 engines after the armistice was signed. Engines were constructed in accordance with this contract under the Dutch Werkspoor patents, but differed from the Dutch designs in having strong cast-iron pedestals in place of the characteristic steel diagonal rods of the Werkspoor design, resulting in a much stiffer engine.

The first engine was given a 32-day continuous test run under full load, and to show the good condition in which the engine was at the end of this run, a 20 per cent overload was put on for several hours before stopping. This engine and a second one, to make a pair of engines, were, with the permission of the Emergency Fleet Corporation, sold during construction to the Standard Oil Company of California, and were installed in the M.S. *H. T. Harper*.

Substantially the same design, now designated as the Pacific Werkspoor design, was followed for two 600-b.hp. engines for the motorship *Charlie Watson* and two 400-b.hp. engines for the Diesel-electric tanker *Standard Service*, all for the Standard Oil Company of California.

The ten engines built for the Emergency Fleet Corporation were sold by the Corporation several months ago, the first one being the engine described by Mr. Crozier for the installation at Tucson, Ariz. Two were secured by the Standard Oil Company of California, and the remainder by various Pacific Coast marine interests.

One of the three purchased by the Lynch and Grey interests has already been installed in the *Frank Lynch*, a Great Lakes type vessel from which the steam plant was taken out. In this installation while under way at sea the exhaust gases from the Diesel engine are passed through a steam boiler, which generates steam for the steering engine and electric-lighting equipment.

The 850-b.hp. and 600-b.hp. engines are of the large, slow-turning crosshead type, but many of the smaller trunk-piston type, the smallest so far being a 70-b.hp. two-cylinder engine, have been built, two of the latter size going to a gold dredge operated in Alaska.

Of the large-size trunk-type engines which have been built and installed on the Pacific Coast, the following are of interest:

A set of three 525-b.hp. engines in a Diesel-electric power station in Nome, Alaska, where the electric power is carried to floating gold dredges through an overhead cable. Two of this same power are in operation on the Diesel-electric ferry *Golden Gate* running between San Francisco and Sausalito. Another pair of these engines is being installed in a sister ship the *Golden West* now being built for the same company and which will soon be in operation. One of these 525-b.hp. engines is being operated in the Columbia River territory.

[1] By C. E. Nagel, chief engineer, Pacific Diesel Engine Co., Oakland, Cal.

The 250-b.hp. engine in four cylinders is another popular size of which many have been installed.

On the whole, there has so far been built 18,000 b.hp. of full Diesel engines in one shop in Oakland, Cal., not a bad record by any means.

Small Marine Motors

The Pacific Coast uses literally thousands of small motorboats fitted with gas engines ranging from the 6-hp. outfit of the crab fisherman through the 80- to 150-hp. launches to tugs of 300 hp. and upward. Designed to operate on the California distillate, a semi-volatile liquid fuel one step downward on the scale from common gasoline, the marine gas engine, usually designated as the Pacific Coast type, is a rugged, heavy-duty, reliable and substantially built machine.

These machines are built in quantities by a dozen or so manufacturers and the gas-engine industry is of considerable importance. Imagine the consternation two years ago when the oil companies, forced by scarcity of suitable refining crudes coincident with increasing demands for gasoline, had to withdraw distillate from the market and were only able to supply gasoline at two and a half times the price.

With twenty years or so of experience back of them in building marine motors to meet the severe Pacific Ocean conditions, what was more logical for the builders than to turn to the Diesel engine for the solution of the problem and to develop from the various types something which would fit the demand.

Increasing quantities of Diesel engines are now being manufactured which are operated on the four-stroke cycle with mechanical airless injection, using an oil pressure of around 4000 lb. per sq. in., and which also have all the excellent features of the marine gas engine, which they are rapidly superseding, being in essentials but little different. The oil-injection pressure is obtained by a two- or three-plunger pump driven off the camshaft and fitted with a relief valve for limiting the pressure. Some engines are fitted with an accumulator also. For idling at reduced speeds means are provided to reduce the injection pressure to 2000 lb. per sq. in. or even to 1500 lb.

The high-pressure oil is injected into the cylinder through an injection valve of the needle type which has a removable tip drilled with a number of small holes ranging from 0.006 in. to 0.01 in. in diameter in the various designs. Regulation is obtained by varying the lift of the injection-valve needle. To facilitate maneuvering all engines are fitted with governors.

A compression of approximately 420 lb. per sq. in. is usual and 390 lb. is the operative minimum below which ignition is uncertain. Pressure during burning of the fuel varies from 450 to 500 lb. per sq. in. and the conditions are in general like those which obtain in the air-injection engine, save that the horizontal admission line of the indicator card of the air-injection engine is usually not realized.

Like the larger Diesel engines, starting is by compressed air, and a small single-acting compressor cylinder is fitted to furnish a supply sufficient for several starts, a small tank being supplied.

As a general rule the marine fraternity has taken well to the new engines and generally the opinion appears to be that they are thoroughly reliable and dependable and easier, if anything, to take care of than the gas engines which it has used for so many years. The great economy in both fuel and lubricating oil is of course an exceedingly important factor.

The fuel supplied by the oil companies as Diesel oil is designated as 24 deg. B., but is sometimes much lighter. The engines will operate on heavier oils, and in fact on practically any clean suitable oil if it is heated to increase the limpidity, although this is not done to any extent as yet.

As Diesel fuel costs around $3^1/_2$ cents per gallon, the fuel consumption of a 100-b.hp. launch working ten hours a day will be about $11 per week as compared to $50 per week with distillate and $100 per week with gasoline. Parenthetically it may be said that distillate is again available since the bringing in of the phenomenal oil fields in Southern California.

Lubricating-oil consumption at the rate of 1 gal. per 1000 b.hp. is claimed, or about half that of the gas engines, which were heavy consumers of lubricants.

Effect of Altitude on Engine Capacity

Whenever inland Diesel installations are contemplated the question of the effect of altitude on the capacity of the engine arises, and in Pacific Coast practice this is of considerable importance because of the high altitudes of our inland states in the Sierra and Rocky Mountain regions. This effect is easily calculated as it is due to the reduction in the weight of air which enters the cylinder at each stroke because of the lower pressure of the atmosphere at higher altitudes. The reduction in capacity of the engine is about $3^1/_2$ per cent for each 1000 feet elevation above sea level, and is not usually taken to account for altitudes up to 1000 feet.

At Tucson, Ariz., for example, altitude 2440 ft., the normal barometer is 27.34 in. as compared to 30 in. at San Francisco, and the atmospheric pressure is 13.4 lb. per sq. in. as compared to 14.7 lb. at San Francisco. In a Diesel engine having a normal compression of 460 to 480 lb. per sq. in. at San Francisco there would be a reduction of this pressure of about 50 lb. In the installation being made at Tucson this is compensated for by making the piston rods slightly longer.

Compensation for the loss in capacity can be made in various ways and for the first few thousand feet is effected in part by making use of the excess capacity of the engine over full rated load, and by making up in part by increasing the amount of injection air used. This is regularly done at Tucson, and is one of the advantages of the air-injection system.

When altitudes of 5000 ft. or more are encountered, an engine may be run up to its full sea-level rating by adding an air compressor and supplying air at a few pounds pressure to the air inlet valves or by using an electrically driven rotary pressure blower, which will raise the pressure about three pounds per square inch.

Diesel Engines for Agricultural Purposes

Waiting for solution by Pacific Coast engineers is the problem of applying of Diesel engines to agricultural purposes, particularly to tractors. Working on an average of 250 days per year as against 20 days per year in eastern usage, California-manufactured tractors have reached a high stage of development.

The farmer needs the benefit to be obtained from use of the cheaper Diesel fuel and also relief from the ever-present crankcase contamination which plays such havoc with his lubricating oil and bearings; and for tractor purposes a high-speed light-weight engine must be developed having all the excellencies of the present new tractor designs and about the same weight.

In Arizona, Nevada, and the inland mountain country where hydroelectric transmitted power is only available in certain territories, large numbers of Diesels are being bought for pumping, a service requiring reliability and durability, and in particular an efficient oiling system covering every bearing so that no attention is required for days or weeks.

Summary

The Diesel industry in California is now manufacturing and supplying engines from 50 b.hp. up to 1000 b.hp. and can handle even larger types, of which satisfactory service records are available. It has built about 40,000 b.hp. to date. Doubtless the limits given above as already attained will be extended both upward and downward. Its great need at present is the confidence of the public in what it is in a position to deliver, and the assurance of the owners that the engines they purchase will be given fair treatment and necessary attention. The general education of the public as to the internal-combustion engine of the automobile and the steadily growing example of Diesel engines of the smaller sizes on the Pacific waters in the hands of fishermen and others of but limited mechanical knowledge will soon create a spirit of confidence which will wipe out the uncertainty which still persists.

While but little has been done in building large Diesel-engine electric central stations of a magnitude similar to the steam plants of the large power companies, there is nothing to prevent its being done, with profit both to the buyer and the builder. It may be pointed out that a Diesel-electric power plant of 10,000 kw. capacity need have no more than forty cylinders in operation to carry full load. Such a station could give instantaneous stand-by service, or, if sufficient reserve units were installed, would be an economical source of primary power.

Canadian and American Engineers Coöperate to Make A.S.M.E. Meeting a Success

Wholehearted Canadian Hospitality, Excellent Technical Sessions and Unusual Entertainment and Excursion Events Make 1923 Montreal Spring Meeting Memorable

THE Spring Meeting of The American Society of Mechanical Engineers, held in Montreal May 28–31, was featured by an interesting program of technical sessions, industrial visits, and entertainments. The registration for the meeting was 631, which included 149 members of the Engineering Institute of Canada and 120 ladies. Although this number was not large compared to the Chicago meeting of 1921 or the Detroit meeting of 1919, it must be remembered that numbers have very little to do with the success of a Spring Meeting; every one who was at Montreal enjoyed it thoroughly and will testify to its successful attributes.

The entertainment and excursion events were conducted in an excellent manner and everywhere there was praise for the Local Executive Committee, made up of H. H. Vaughan, Chairman, Major J. A. Duchastel, Vice-Chairman, Fraser S. Keith, Secretary, and Fred. B. Brown, John T. Farmer, George R. MacLeod, and Major C. M. McKergow. The unusually large number of ladies at this meeting made the entertainment features very enjoyable. The ladies were received by a committee made up of the wives of the Local Executive Committee, with Mrs. Fred. B. Brown as chairman. The *A.S.M.E. News* of June 7 contained an account of the entertainment and excursion features.

The feature of the technical sessions at Montreal was the wholehearted manner in which the engineers of Canada coöperated in the meeting. Of the seventeen papers presented at the meeting, seven were written by Canadians, and their contribution to the program will have a notable effect in increasing the understanding by Americans of the problems and progress of the Canadian engineer. The American Society of Mechanical Engineers was fortunate to have on its program such exponents of hydroelectric power development as Julian C. Smith of the Shawinigan Water and Power Company, and Frederick A. Gaby of the Hydro-Electric Power Commission of Ontario. H. G. Acres, of the Ontario Hydro-Electric Power Commission, presented an exceedingly interesting paper on large hydraulic turbines. Fred W. Cowie, Chief Engineer of the Montreal Harbor told of the remarkable accomplishments in the harbor of Montreal. J. A. Wilson, General Secretary of the Canadian Air Board, explained the progress made by the Canadian Government in encouraging and regulating aviation. The two papers on the program for the Railroad Session were presented by Canadians, H. R. Naylor of the Canadian Pacific Railroad and C. E. Brooks of the Canadian National. In this manner, therefore, the Canadian engineers coöperated most wholeheartedly and substantiated the sentiment expressed by the President of the Engineering Institute of Canada in his opening remarks that the engineering profession, as such, recognized no international boundary.

The Council of The American Society of Mechanical Engineers was very well represented at the meeting, there being only four absentees. However, there were nine past-presidents on hand for the deliberations and for the enjoyable dinner which was tendered by the Council of the Engineering Institute of Canada to the A.S.M.E. Council.

Business Meeting

THE first session was the Business Meeting of the Society, held Monday afternoon, May 28. Walter J. Francis, President of the Engineering Institute of Canada, spoke a few words of warm greeting on behalf of the engineers of Canada and emphasized the community of interest among engineers. President Harrington responded in kind.

The only matter of business was the announcement of Cleveland, Ohio, as the place for the 1924 Spring Meeting of the Society. John Price Jackson, Mem. A.S.M.E., and Executive Director of the Sesqui-Centennial Exposition to be held in Philadelphia in 1926, was then introduced. Mr. Jackson explained the importance of the coming exposition not only as a record of the remarkable advances in science and industry in the immediate past but as an inspiration for tremendous new advances.

The business meeting was then turned over to Calvin W. Rice, Secretary of The American Society of Mechanical Engineers, who delivered his travelogue on his trip to South America, when he bore credentials from the Engineering Institute of Canada to the South American Engineering Congress. This was the first opportunity given to members of the Engineering Institute of Canada to hear the report from the Congress and the account of Mr. Rice's trip through South America.

First Power Session

PROF. A. G. Christie of Johns Hopkins University, Past Chairman of the Power Division and Member of the Council, A.S.M.E., called the first Power Session to order on Tuesday morning, May 29, and introduced Philip S. Gregory,[1] who presented the paper by Julian C. Smith, Chief Engineer of the Shawinigan Water and Power Co., on Power Development in the Province of Quebec. Mr. Gregory was followed by Fred A. Gaby, Chief Engineer of the Hydroelectric Power Commission of Ontario, who presented the paper on the development of Hydroelectric Power Plants in Ontario. These two papers and the discussion contributed by F. Darlington of New York,[2] John R. Freeman[3] of Providence, and William M. White[4] of Milwaukee, appear in generous abstract on preceding pages of this issue of MECHANICAL ENGINEERING. The program for this session was arranged for the Power Division by the Montreal Committee.

Management Session

DEAN Dexter S. Kimball, Past-President of the A.S.M.E., wielded the gavel at the Session on Management, Tuesday morning, May 29, the program for which had been provided by the Management Division.

The paper by R. B. Wolf[5] on Management Engineering in the Paper Industry was read first. This paper appeared in the May issue of MECHANICAL ENGINEERING. The discussion on Mr. Wolf's paper was opened by L. W. Wallace,[6] who agreed with Mr. Wolf that the most difficult problem in installing improved management methods was in overcoming the non-response of superintendents and foremen. Mr. Wallace also agreed that a correct approach to the solution to this problem was the stimulation of interest in production achievements and costs. He emphasized the need for measuring the performance of the individual operators and the provision of an adequate avenue of self-expression for the individuals in industry.

Wallace Clark[7] agreed in the main with the statements made by Mr. Wolf but he pointed out that while departmental cost sheets are practical in continuous industry, they are difficult to secure in a non-continuous industry, where the cost of idleness is not maintained separately from the cost of work done. Mr. Clark also emphasized the need of translating costs to time, which is an element which the operator understands. He knows that he should accomplish a certain amount of work in a certain time;

[1] Asst. to Vice-Pres., Shawinigan Water Power Company, Montreal, Can.
[2] Cons. Engr., 165 Broadway, New York.
[3] Pres. Mfrs. Mut. Fire Ins. Co. Past-Pres. A.S.M.E.
[4] Mgr. Ch. Engr., Hyd. Dept., Allis Chalmers Mfg. Co Mem. A.S.M.E.
[5] R. B. Wolf Co., New York, N. Y. Past Vice-Pres., A S M.E.
[6] Exec. Sec., Federated American Engineering Societies, Washington, D. C. Mem. A.S.M.E.
[7] Indus. Engr., New York, N. Y. Mem A.S.M.E.

and if the time he consumes is compared by the Gantt chart with some sort of standard of time necessary, great improvements in operation will result. Mr. Clark stated that the important factors to be evaluated are whether the machines are running and whether operators are doing their work within an estimated time.

In answer to a question as to the cost of clerical work for a cost system, Mr. Wolf stated that in one particular plant by adding $13,000 a year to the engineering and clerical force, the first year's actual saving was approximately $40,000.

In closing the discussion Mr. Wolf admitted the difficulty of developing departmental cost sheets in a non-continuous process factory. Mr. Wolf did believe, however, that in a department organized for a specific purpose, a measurement of accomplishment was necessary to develop the individuality of the department.

The question of industrial engineering education has always been a prolific source of discussion. The paper by Professor Myron A. Lee[8] on a Practical Laboratory and Drawing-Room Course in Industrial Engineering, was no exception and discussion was contributed by a large number of educators and industrial engineers. Professor Lee's paper, with the discussion, will appear in the August issue of Mechanical Engineering.

The Railroad Session

The Railroad Session with the program prepared by the Railroad Division was presided over by H. H. Vaughan, Member of the A.S.M.E. Council. The first paper presented was by H. R. Naylor,[9] on Steel Car Construction at the Angus Shops of the Canadian Pacific Railroad. This paper appeared in the June issue of Mechanical Engineering. In the discussion Ernest R. Viberg[10] stated that the box car is one of the most important element of stock equipment used by the railroads. He ventured to guess that the railroads of Canada and the U. S. used about 250,000 box cars of the steel-frame, single-sheathed type.

F. O. Whitcomb,[11] discussed the subject of car construction from the point of view of the contract shop. The diversity of types and sizes of cars and the small orders executed at one time at such a shop precluded the spending of money on large special tools. The railway men could work with the car designer and build the cars around existing tools. Mr. Whitcomb believed that the jig method of assembling freight cars was more expensive than the skid method, in which in six positions the underframe was sheathed and assembled, then placed on its own trucks and in ten moves was ready for the woodwork. Under such an arrangement an average of forty-two cars per day for over a month had been made, with 52 in one day of eleven hours as the maximum. Mr. Whitcomb mentioned the use of electric rivet heaters as a desirable economy and endorsed the continuous painting machine described by Mr. Naylor. Max Toltz[12] expressed the opinion that the dead weight of the car could be considerably reduced, for reducing dead weight was necessary if greater economy of operation was to be attained. Mr. Toltz recommended the consideration of alloy steel in cars under construction. Augustus Smith[13] pointed out the need for designing bodies of cars that would lend themselves more readily to handling contents mechanically.

In closing the discussion, Mr. Naylor expressed the opinion that by use of the jig method a tighter box car is secured, and in enumerating the various moves under the system of jig assembling, he found only six. Mr. Naylor reported that electric rivet heaters were not found satisfactory. He also stated that the proportion of dead weight to limit loads in steel box cars had not increased as the size increased.

The paper by C. E. Brooks[14] on More Recent Developments of the Motor Coach treated of a subject which is only in the earliest stages of development but covers a large field and variety of equipment. Mr. Brooks' paper precipitated a discussion as to the relative merits of the gasoline motor car and the electric storage-battery car. The paper with the discussion will appear in the August issue of Mechanical Engineering.

[8] Asst. Prof. Indus. Engrg., College of Engineering, Cornell University, Ithaca, N. Y. Mem. A.S.M.E.

[9] Asst. Works Mgr., Angus Shops, Canadian Pacific Ry. Co., Montreal, Can.

[10] Mech. Engr., Canadian Car & Foundry Co., Ltd., Montreal, Can. Mem. A.S.M.E.

[11] Canadian Car & Foundry Co., Ltd., Montreal, Can.

[12] Toltz, King & Day, Inc., St. Paul, Minn. Vice-Pres. A.S.M.E.

[13] Bergen Point Iron Wks., Bayonne, N. J. Mem. A.S.M.E.

[14] Mech. Asst., Canadian National Railroad, Toronto, Can. Assoc-Mem. A.S.M.E.

Second Power Session

A. G. Christie, Member of Council, A.S.M.E., presided Wednesday, May 30, at the second session under the auspices of the Power Division. Two papers were presented: the first, by H. G. Acres,[15] was entitled Modern Hydraulic Turbines of Large Capacity, and the second, by Peter Payne Dean,[16] Sectionalization and Remote Control of High-Pressure Steam Lines. Mr. Acres' paper brought out considerable interesting discussion on the various mechanisms in use in modern large-capacity hydraulic power plants. The paper will appear in the August issue of Mechanical Engineering with the discussion, as will also the paper by Mr. Dean and its discussion.

Port Development

The program on Port Development was arranged by the Materials Handling Division, and its chairman, H. V. Coes, presided at the session on Wednesday morning, May 30. The first speaker was Fred W. Cowie,[17] who gave a broad outline of the port development of Montreal. Mr. Cowie has served as chief engineer for the Montreal Harbor Board for sixteen years and is recognized as an authority on transportation and harbor development. A second paper was presented by Carroll R. Thompson, Assistant Director of Wharves, Docks and Ferries of the City of Philadelphia. Mr. Thompson's paper was a résumé of the papers presented under the auspices of the Materials Handling Division at various Atlantic seaports during the past year. The papers by Messrs. Cowie and Thompson with the discussion will appear in the September issue of Mechanical Engineering.

At the close the chairman presented a report of a committee appointed by the Materials Handling Division to devise a formula which might be used in determining the justifiable investment for labor-saving machinery. The report of the Formula Committee will be presented in the August issue of Mechanical Engineering.

Textile Session

The textile program, arranged by the Textiles Division, consisted of one paper which was presented on Wednesday morning, May 30 with C. R. Main, member of the Executive Committee of the Textiles Division, in the chair. Under the title Bleachery Engineering and Operation, the authors, Frank P. Bascom[18] and J. C. McDowell,[19] explained the extreme complication of the process of converting gray cotton cloth into bleached, dyed, or printed fabric. They emphasized the artistry required by the bleacher, the finisher, and the dyer in working the raw material and producing the final result that would be pleasing and useful to the discriminating housewife. They showed the difficulty of determining the exact amount of starch required merely by the feel of the goods and the exact quantities of dyes to be used. as examples pointing to the need of great experience and familiarity of the bleachery foremen with processing methods. Great care must be exercised. The authors visualized an ideal plant and briefly traced the goods through the various processes. They pointed out that the grouping of operations formerly conducted independently is the most important recent development in the bleaching industry. By the use of variable-speed motors driving the various units, the cloth may be led from one machine to the next and with automatic speed controls the tension of the cloth from machine to machine and process to process may be properly maintained. In this grouping of units for continuity of processing lies the key to rapid production

[15] Hyd. Engr., Hydro-Elec. Power Comm. of Ontario, Niagara Falls, Ont., Canada.

[16] Payne Dean, Ltd., Stamford. Conn.

[17] Chief engineer, Harbor Commissioners, Montreal, Canada.

[18] Supervising Engineer, Lockwood, Greene and Co., Boston, Mass.

[19] Lockwood, Greene and Co., Boston, Mass

and minimum operating costs. Economical handling of materials is a point of great interest to the plant designer. The provision of proper water is also an item of great importance; for high-class work, many plants require elaborate water-filtering and purifying apparatus. In all problems of bleachery design it is necessary to study local conditions, goods to be treated, the results desired, and apply a thorough knowledge of proper equipment and methods.

Fuels Session

TWO interesting papers presented at the Fuels Session on Thursday morning, May 31, brought forth considerable discussion. The program was arranged by the Fuels Division and the session was presided over by Fred R. Low, chairman of the Division. Chimney Sizes was the title of a paper by Alfred Cotton[20] which was presented at the meeting by E. R. Fish.[21] This paper will be abstracted in a later issue of MECHANICAL ENGINEERING.

The second paper, on Lignite Char, appeared in the May issue of MECHANICAL ENGINEERING. In presenting it, O. P. Hood,[22] the author, submitted considerable additional information. He called attention to the apparently abnormal fact that people in some of the western states were living on a bed of fuel and yet burning coal brought from a distance of 1000 to 2000 miles. While comparatively unimportant in ordinary times, this threw an apparently unnecessary burden on the transportation system of the country in time of war, and was one of the circumstances that led to undertaking the investigation described in his paper.

The main difficulty in developing the lignite-char industry at present, he said, was economic. Nobody knew whether the product would find a steady market, and until this had been determined the industry could not be developed. Present stoves and furnaces would not burn it, and there would be no stoves to burn it until there was a lignite char that could be bought freely on the market, and it was difficult to produce the material in quantity until there was a market for it. Furthermore, production of lignite char was supposed to require fairly expensive equipment and this constituted a serious obstacle in two ways. In the first place, no one cared to make the heavy investment necessary for the experimental period in view of the general uncertainty of both the technical and commercial elements of the proposition; and, secondly, lignite mines were comparatively small and it did not appear commercially attractive to put up expensive furnaces in connection with mines of limited output.

This affected the by-product phase of lignite coal manufacture. The business of making lignite char with the saving of by-products was essentially a large-scale business. As such, it required very considerable investments which financial people were not ready to make, particularly as lignite mines were in districts only thinly populated (e.g., North Dakota and Texas) where both the economic and labor conditions were unsuitable for big industrial developments.

Of late, however, the Bureau of Mines had developed an experimental furnace and several hundred tons of char had been produced. The char, in general, was the result of the concentration of about $2^1/_2$ tons of lignite into one ton of char. Whatever ash there was in the original lignite would be found in the char multiplied by $2^1/_2$. The volatile matter in the char was controlled within certain limits but in general ranged from 8 to 12 per cent. The fixed carbon was 65 to 70 per cent, the moisture practically nil. This coincided closely with the analysis of anthracite coal. The grains of char were not as hard as anthracite, were clean, and did not break with weathering. One of the favorable characteristics of char was that there was practically no carbon in the ash, in addition to which the char had the ability to hold the fire and burned out very much as a piece of charcoal did. Lignite char ignited much easier than anthracite—in fact, the fire could be started with paper.

All that was necessary to make char was to heat the lignite. The moisture came off first; then if heating was continued to a higher temperature, volatile matter began to come off.

The lignite char when burned in a base burner gave service comparable with anthracite coal, but required an adapter on the ordinary grate of the base burner. Efforts to obtain a similar simple solution to the cook-stove problem and the house-heating furnace had not succeeded, and apparently an entire remodeling of the two furnaces would be required to fit them for burning char.

It was possible to produce lignite char at the mine at about $5 per ton, allowing $1.50 to the mine operator for his slack, and obtaining at this price a fuel of 12,000 B.t.u. per lb. This made the proposition worth serious consideration.

Max Toltz,[23] among other things, called attention to the developments in lignite and brown-coal utilization in Germany resulting from the pressure of economic conditions. Their central power plants were built adjoining lignite deposits so that the mined fuel could be supplied to the grate of the boiler without being stored, for storage disintegrated or slacked this fuel. In one of these central stations which delivers electrical power to cities within a radius of 120 miles, the majority of the boilers were equipped with step grates upon which the lignite was burned successfully. Chain-grate stokers were also used, but care was required as part of the finer lignite would sift through the grates into the ashpit. This station consumed 900 tons of brown coal every 24 hours.

Another successful appliance for using lignite under boilers was a combination of a semi-gas producer and step grates. The furnace was of the Dutch-oven type projecting in front of the boiler which had a gas-producer chamber partitioned off from the lower step grates by a wall and arch with an opening in the top through which the gases escaped into the combustion chamber over the step grates. The lignite was not fully consumed in the producer, but fell through the bottom of the producer upon the step grates where final consumption of the fuel took place.

The gases of combustion from this fuel upon the step grates combined with the gases leaving the producer and were ignited by an arch back of the grates. The process that took place in the producer was nothing less than that of low-temperature carbonizing of the fuel, so that the lignite falling to the grates was practically half coke. The air for combustion was partly supplied by fans under the step grates and partly (after being heated in ducts of the setting) at a point under the back arch. The latter air would mix with the gases of combustion from the grates and from the producer. The following results had been obtained in this kind of longitudinal boiler installation with lignite of 5400 B.t.u. containing 43 per cent moisture and 6 per cent ash:

Evaporation from and at 212 deg. fahr.	6.9 lb.
Efficiency of furnace and boiler	66 per cent
Chimney losses	21 per cent
Losses due to ashes, radiation	12.5 per cent
CO_2	13.5 per cent

It was claimed that when using part of the chimney gases for predrying the lignite a furnace and boiler efficiency of from 75 to 80 per cent had been obtained. The rate at which lignite was burned per square foot of grate per hour was from 60 to 100 lb., and when peat was burned, up to 130 lb. In addition to these processes, other ways had been developed for the recovery of by-products.

The speaker stated further that some months previous a chemist in St. Paul had demonstrated by a laboratory test that North Dakota lignite could be briquetted without a binder after the sulphur had been extracted. No further details could be given regarding this, but it might lead to some briquetting process, which, if successful, would at least take care of the fuel supply of the Northwest for domestic purposes. During last winter about 5000 tons of North Dakota lignite had been shipped to St. Paul and Minneapolis and used for domestic purposes under special instructions given the consumers by the mine owners. Those who had used this fuel had been satisfied with it, although there had been a general complaint regarding the odor arising from its combustion.

In conclusion Mr. Toltz said it was gratifying to report that besides the U. S. Bureau of Mines, the Mining Department of the University of North Dakota as well as the Government of the Province of Saskatchewan were working for better methods of

[20] Chief, Research Dept., Heine Boiler Co., St. Louis, Mo. Mem. A.S.M.E.
[21] Vice-Pres., Heine Boiler Co., St. Louis, Mo. Mem. A.S.M.E.
[22] Chief mechanical engineer, U. S. Bureau of Mines, Washington, D. C. Mem. A.S.M.E.
[23] Toltz, King & Day, Inc., St. Paul, Minn. Vice-Pres. A.S.M.E.

utilizing lignite, and it was hoped that in the near future the value of this fuel as a source of power, domestic or industrial, would be determined so that at least the northwestern part of the United States, as well as the central provinces of the Dominion of Canada, would derive the benefit of their lignite resources which were now practically lying idle.

Leslie R. Thomson of Montreal, Secretary of the Lignite Utilization Board of Canada, told about the Board and its work. It was a body representing the Dominion Government and the governments of the provinces of Manitoba and Saskatchewan, created in 1918 to demonstrate the commercial possibilities of providing a high-grade domestic fuel to compete with American imported anthracite in the Canadian Central West. The problem was limited to the Central West because as one moved westward from Mid-Saskatchewan the decrease in price of fairly good Alberta coal made it impossible for an expensive briquet to compete. The Board was mainly concerned with the production of a high-grade domestic fuel and did not touch the power question.

The problem of handling Canadian lignites was made increasingly difficult by the fact that they were hygroscopic and if exposed to the air after drying reabsorbed moisture to the extent of from 15 to 17 per cent.

Operation based on the recovery of by-products was out of the question in Canada as far as by-products of the fertilizer type were concerned, because, owing to local agricultural conditions, there was no demand for fertilizers. The only by-product likely to have an immediate market was a motor fuel.

The experimental work done by the Board was described in some detail. Several sizes of retorts were built one after another. All gave trouble at first, but were made to produce ultimately. Even now the operation was too expensive and could not be termed commercial, the main troubles being due to poor floor material and lack of a satisfactory refractory. A carbonizer was being erected now.

Certain technical and commercial points had been discovered in the course of this work. It was found that the B.t.u. content of char varied with the temperature of carbonizing, the curve reaching its peak at 1050 B.t.u. The next point was that char could be sold in the Canadian Northwest only if briquetted.

As regarded sizes, the char would pass through a $^1/_8$ mesh and be retained on about 170 or 180.

The only criticisms offered for the future of the retort were the two points mentioned by the author, one of which was that it was necessary to feed it certain screened sizes. In a country where there was a large amount of lignite slack and small sizes it would seem expedient when attempting to make a high-grade fuel to buy the original fuel of the cheapest material. If the retort would not use that, one very large portion of the possible supply would thus be limited. The second criticism was on the fact that although there was provision for a small amount of by-product recovery, the final solution of lignite retorting must be found, especially as the population increased, in a retort that would give the by-products if and when necessary.

E. N. Trump[24] told of what he had seen in Germany in 1913, in particular the type of furnace for carbonizing lignite. This was a cylinder about 12 ft. in length, lined with refractory brick. At the end away from the furnace was a hole through which the air for combustion entered. That furnace gave a long flame of a very high temperature and the lignite going into it was first dried by the heat from the brick and then as it became char it burned by the direct entrance of the air at the other end, which was regulated. The air was not supplied in sufficient quantities to entirely consume the fuel. The arrangement appeared to be superior to the step-grate furnace and used lignite without any previous preparation.

Col. H. D. Savage[25] stated that the simplest and most efficient way of burning lignite was in powdered form. In tests made some years ago, about seven carloads of lignite had been burned in pulverized form without any change in the plant and with an efficiency of about 78 per cent. More recently in another plant five carloads of lignite of good grade from Colorado were burned likewise in pulverized form without any difficulty. According to the speaker, drying of lignite did not seem to be necessary and moisture up to 22 per cent did not create any difficulty in burning lignite in pulverized form. A plant was now being built at Boulder, Col., to utilize that coal with the necessary rating.

In his closure Mr. Hood stated that there did not appear to be any need of processing lignite when it was to be used for steam-making purposes, and mentioned some tests of burning lignite on a chain-grate stoker.

Answering a question as to whether the experimental device used the heat in the gases, Mr. Hood said that the gases left the device at a low temperature. In fact that was one of the troubles encountered; the gases went off at such a low temperature that they did not burn. The smell was too much for the college campus and it was found necessary to raise the temperature of the gases in order to burn it. One speaker had remarked about reducing the sulphur content of lignite—which was, by the way, already low—and thereby obtaining a product which would briquet. It was interesting to put this in juxtaposition with a statement that came from Oregon, where, with their lignite, by the addition of sulphur they were now producing a briquet.

Mr. Hood called particular attention to the fact that what was known in Germany as "Braunkohle," or brown coal, was not the same thing as the lignite found in this country. The distillation of brown coal was very interesting. If one looked at the bed of brown coal as it lay in the ground in Central Germany, one would notice the bonded formation. Some of it was very light, some would be dark cream color, varying all the way from that to a barely distinguishable lighter shade than the black-brown of the main body. It was these special veins or beds that were used for distillation purposes. Instead of mining the whole mass these beds were mined by hand and kept separate from the rest. Some of it would run as high as 13 per cent in paraffin. When it was considered that the moisture content of that was about 50 per cent, it meant a very high percentage of paraffin on a dry basis. That paraffin was the base of a considerable string of products, one of which was the lubricating oils. They were not taking the whole lignite but taking particular pieces. We in America had our own material and problem and must solve it in our own way and not merely import a way from abroad.

Machine Shop Session

On THURSDAY morning, May 31, the session on Machine-Shop Practice was held with F. O. Hoagland, Chairman of the Machine Shop Practice Division, presiding. The first paper presented was that of C. R. Söderberg[26] on Recent Developments in Balancing Machines. Mr. Söderberg's paper appeared in the June issue of Mechanical Engineering.

In opening the discussion, G. M. Eaton[27] pointed out that the use of balancing machines for electric rotating apparatus has largely been confined to the works of electrical manufacturers. The shop for maintaining electric machinery finds it extremely difficult to balance rotors of machines being repaired. In view of this, Mr. Eaton stated that the aim of the manufacturers should be to reduce the necessary balancing operation to the simplest procedure in keeping with the fundamental requirements. Mr. Eaton also stated the importance of rendering balancing machines available either by installing such mechanisms in centrally located service stations or by the introduction of portable balancing machines. At present it was generally believed that if service conditions were rough, running balance was an expensive luxury and attention was focused exclusively on making the apparatus rugged and the resulting maintenance expense accepted as a necessary evil. This old belief, however, was being shaken by researches into vibration disturbance and resulting fatigue phenomena. Mr. Söderberg's paper was therefore regarded as very timely.

Carl A. Johnson[28] presented a description of the Newkirk balancing machine. C. C. Brinton[29] pointed out that the development

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[25] Combustion Engineering Co., New York, N. Y. Mem. A.S.M.E

[26] Westinghouse Elec. and Mfg. Co., East Pittsburgh, Pa.
[27] Ch. Mech. Engr., Westinghouse Elec. and Mfg. Co., East Pittsburgh, Pa. Mem. A.S.M.E.
[28] Pres., Gisholt Mch. Co., Madison, Wis. Mem. A.S.M.E.
[29] Asst., Supt. Westinghouse Elec. and Mfg. Co., East Pittsburgh, Pa.

of the future should be a line of portable balancing machines where accuracy was essential and production not a requirement. He stated that one type of shaft which had given trouble in obtaining good balancing was the three-bearing type with two rotors on the same shaft.

In closing the discussion, Mr. Söderberg answered a question as to the practicality of balancing a centrifugal pump rotor that the problem could be solved by mathematical analysis. He pointed out that the difficulties of balancing were multiplied many times when working with small rotors.

After Mr. Söderberg's paper was presented, there was a symposium on the Machine Tool and the Pulp and Paper Industry. Six written discussions were presented with a foreword by George E. Williamson[30] who pointed out the probability that the interrelation of the machine-tool industry and the paper and pulp industry had not been given the detailed study which the subject warranted.

In the first three of this group of discussions, shop problems in paper-machinery manufacturing and the general requirements of the machine tools employed therefore were dealt with by E. T. Spidy,[31] Geo. S. Barton,[32] and H. L. Kutter.[33]

Mr. Spidy spoke of the shop problems involved in the building of the modern newsprint machine, approximately 300 ft. long 14 to 20 ft. wide, and containing 800 tons of metal, as well as the methods of scheduling to insure delivery in the six to seven months allowed for that purpose. He described, among other operations, the methods used in casting and machining driers 20 ft. long by 5 ft. in diameter; straightening, grinding, and balancing the various types of rolls; the securing of interchangeability; methods of erection, etc.

Mr. Barton pointed out that the paper-making machine was not a precision tool, and while many of its parts were often finely and accurately made, nevertheless the tolerances as to bearing sizes and other machined surfaces were far more liberal than was customary or even permissible in machine-tool construction. Every shop building paper machinery should be provided first of all with heavy-duty lathes capable of swinging parts 72 in. in diameter by 20 ft. long and weighing 15 to 20 tons. One of these lathes should be fitted with a boring bar.

Mr. Kutter stated that the general tool requirements of shops making paper-mill machinery were substantially those of establishments doing general heavy work in which no extensive standardization was possible. In addition to the heavy-duty lathes mentioned by Mr. Barton and the more common tools used in machine shops, he enumerated lathes for machining press rolls (32 in. swing by 25 ft. between centers); special machinery for grinding press rolls; a 300-ton hydraulic press for forcing bronze jackets over press rolls; lathes for machining felt and paper-carrying rolls made of pipe or steel tubes (24 in. swing by 23 ft. between centers); a hydraulic machine for straightening these tubes or pipes; planers up to 84 in. wide, and boring mills taking work up to 10 ft. in diameter.

Jas. A. Cameron[34] discussed the plant equipment necessary for producing paper-working machinery. In this class were included paper-coating machines, slitting and roll-winding machines, printing machinery, machines and appliances for making boxes, envelopes, bags, etc. Such machines were built in so great a range of types and sizes for specific requirements that there was no such thing as standardized shop facilities in connection with their manufacture. A web press might accommodate a web 12 in. or less wide for tickets, or more than 6 ft. wide for magazines. Boxes, bags, envelopes, tubes, etc., varied so much in size, kind, and style that shops building the machinery to make any of these products must be equipped for all-round work.

Edward Hutchins[35] and E. B. Wardle[36] dealt with the requirements of pulp- and paper-mill repair shops. Mr. Hutchins called attention to the fact that practically all repair work not caused by actual breakdown of machinery must be done on Sundays and holidays. The paper-mill repair man had to be an all-round mechanic who had great pride in his ability to do a good, rugged piece of repair work with makeshift tools and materials when such work was necessary to keep the plant in operation. The equipment of the repair shop must be suited for work on large and heavy machine parts and must be reliable, simple, and easy to run. On account of Sunday and holiday operation of the tools motor drives were to be preferred.

Mr. Wardle stated that as pulp and paper mills ran continuously on a schedule of six days per week, it was essential to minimize loss of production by making repair parts in advance when the need for them could be foreseen, and by installing necessary equipment to make quick repairs in emergencies. Mills making paper and pulp were naturally located where the supply of wood and power was most plentiful and suitable. This generally meant that the location was more or less remote from centers where facilities were available for repair work, and such mills must therefore be equipped with tools to handle anything up to rolls weighing 25 tons and 25 ft. in length. Both Mr. Wardle and Mr. Hutchins gave lists of the various machines that should be included in the equipment of such repair shops.

An understanding of the far-reaching importance of the work of the Machine-Shop Practice Division in American industry was convincingly demonstrated in the report of the Special Committee on Plan and Scope, which presented its report at this session.

The Committee recommended that the activities of the A.S.M.E. in the field of machine-shop practice be as follows: (*a*) To promote the art of machine-shop practice; (*b*) To encourage original research in the machine-shop field; (*c*) To foster education in machine-shop practice, and to persuade educational institutions to increase their attention to this subject; (*d*) To advance the standards of machine-shop practice, and its exact knowledge; (*e*) To promote the intercourse of those engaged in machine-shop practice among themselves and with the other members of the Society, and with other societies. To carry out these activities the Committee recommended an organization of sub-committees and outlined their relation with the present Executive Committee. To understand the broad scope of the plan, attention is called to the fact that the Division intends to search out for papers, information of a fundamental and research nature applicable to all machine shops. As such papers cannot be obtained on the spur of the moment or even on several months' notice, the new Sub-Committee on Planning is charged with the responsibility of laying down a ten-year plan under which the various shop processes can be taken up. By laying plans thus far ahead, it will be possible to keep in touch with the experimental work of various kinds, and when its development is sufficiently advanced, arrange to have it presented before the Society. The Committee also analyzed the various products that might well be considered in the field of the Machine-Shop Practice Division and the various processes employed in their manufacture.

The Committee on Plan and Scope consists of K. H. Condit, Chairman, A. L. De Leeuw, Erik Oberg, Earle Buckingham, J. J. Reynolds, Frederick Franz, and W. J. Peets.

General Session

THE ONLY General Session of the Meeting was held on Thursday morning, May 31, with Earl F. Scott, member of the Council, acting as presiding officer. A paper on the Control of Civil Aviation in Canada was presented through the Aeronautic Division by J. A. Wilson[37] Secretary of the Canadian Air Board. Mr. Wilson's paper, which will appear in a later issue of Mechanical Engineering, treats of international flying regulations and the rules in force in Canada for the development of safe flying. The subject of Endurance Data and Its Interpretation was treated by K. Heindlhofer[38] and H. Sjövall.[39] Their paper will appear in a later issue of Mechanical Engineering, as will the paper on the Bending Stresses in Curved Tubes of Rectangular Cross-

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[31] Asst. Supt., Dominion Engineering Works, Ltd., Montreal, Canada. Assoc-Mem. A.S.M.E.

[32] Pres., Rice, Barton and Fales, Inc., Worcester, Mass. Assoc-Mem. A.S.M.E.

[33] Secy., The Black-Clawson Co., Hamilton, Ohio. Mem. A.S.M.E.

[34] Pres., Cameron Machine Co., Brooklyn, N. Y.

[35] International Paper Co., New York, N. Y.

[36] Ch. Engr., Laurentide Co., Ltd., Grand Mere, P. Q., Canada.

[37] Secy., Royal Canadian Air Force, Ottawa, Canada.

[38] Research Eng., SKF Industries, Philadelphia, Pa. Mem. A.S.M.E.

[39] Research Engr., SKF Industries, Philadelphia, Pa.

Section by S. Timoshenko[40] which was presented at this session by title.

Public Hearings and Committee Meetings

FRED R. LOW, Chairman of the Main Committee on Power Test Codes, presided at the Public Hearing on Tuesday, May 28, at which the Codes on Internal-Combustion Engines and two chapters of the Code on Instruments and Apparatus were presented. A number of suggestions were received and referred to the Sub-Committees interested for their guidance in completing the codes.

In connection with the recent revision work on the Boiler Code, sufficient progress has been made by the Sub-Committee on Rules for the Care of Power Boilers and on Rules for Inspection of Materials and Boilers, so that their preliminary reports were submitted to Public Hearing at the Spring Meeting. The hearing on the Proposed Rules for the Care of Power Boilers was on Tuesday, May 29, while the hearing on the Proposed Rules for Inspection of Materials for Boilers was held on Wednesday, May 30. Both hearings were well attended and developed valuable suggestions in regard to the proposed new sections of the code.

The results of years of effort on the part of the Research Sub-Committee on Fluid Meters, were presented in a report at an open meeting on Thursday, May 31, for discussion and comment. The report is in the form of a reference book on flow meters of all kinds and is in two parts. Part I treats the general types of meters as well as the principles and methods involved and gives information which may in many cases be applicable to various commercial meters. Part II gives more detailed information concerning the practical use of all the flow meters now in common use. The discussion at the open meeting brought out a great many valuable suggestions that will be followed by the committee in the completion of its report. The work will be brought up for further public consideration at the Annual Meeting of the Society in December.

On Thursday, May 31, the regular May meeting of the A.S.M.E. Boiler Code Committee was held, at which there were present, in addition to a splendid representation of the Committee members, inspectors from the Canadian provinces and boiler manufacturers and engineers from distant points who are interested in the Committee's activities. The program of this meeting involved the usual interpretation work and a number of official communications in regard to boiler-construction matter.

Hydroelectric Possibilities of Quebec

(Continued from page 409)

b Troubles occurring in the water channels above or below the power house affecting the head acting on the turbine.

To a large extent the troubles in classification (*a*) have been overcome by better design of the power house and better knowledge of the cause of these troubles. By enclosing the rack structure and by getting the turbine chambers warm and in general by the use of larger units, much of the trouble which was experienced formerly has vanished. The other trouble is more difficult to remedy, and inasmuch as the change of levels may be due to blockades of considerable area, the remedy in most cases is peculiar to the power development.

Most plants on the St. Lawrence River experience variations in height of headwater or tailwater due to ice blockades at long distances from the power house. On smaller streams, and particularly on very small streams, these blockades may be extremely serious, as they may and do affect a large portion of the flow of the river.

In large power developments, ways and means have been developed which minimize to a considerable extent these difficulties, and the expense of carrying out such efforts is justified in case of large plants where it would not be in small ones. By keeping the channels open to permit the frazil ice to come up to the surface, and by the use of various skimming devices for keeping rid of this ice, a very considerable degree of success has been obtained at the Cedars Rapids plant on the St. Lawrence River. It may fairly be stated that while this ice difficulty was a serious menace some years ago, now such is not the case, provided the plant is a large one and has been located and built with the knowledge acquired from the operation of existing installations.

The growth of hydraulic and hydroelectric development has been rapid and continuous over the past twenty years. The yearly rate of increase has been about seven per cent of the installed capacity per year over the last fifteen years, and the present total development is 1,070,000 hp. of hydraulic and electrical capacity combined.

At the present rate of increase the total available amount of hydraulic power, which is estimated at 5.25 million kilowatts or about seven million horsepower, will be developed and utilized in the next twenty-nine years. However, as the increase in development will in general follow the increase in population, it will take considerably less than twenty-nine years to develop all the power now in sight, and a careful study indicates that in twenty to twenty-five years the 7,000,000 hp. will be used up. Further, this time might be materially shortened if any large amount of power were exported from Canada.

[40] Consulting Engr., Vibration Specialty Co., Philadelphia, Pa.

Feedwater Heating and Plant Economy

(Continued from page 420)

from the house turbine is much less efficient than by bleeding the main unit, there being an advantage of approximately 1.85 per cent in favor of bleeding the main unit. This has led to a change in the type of house turbine installed. The tendency seems to be to carry only as much load on the house turbine as is necessary for the sake of reliability, paralleling the house turbine with the main unit and carrying all the load on the main unit, the switch being so arranged that in case of a heavy overload on the system, the house turbine with certain auxiliaries will pull away from the main unit and the house turbine will carry these auxiliaries at a slightly lower frequency until such time as the load can be again picked up by the main unit. The latest proposition is to carry no load on the house turbine but have it running so as to be able to pick up the necessary auxiliaries in case of trouble to the main unit. With this latter arrangement it is proposed to run a small pipe from the exhaust end of the house turbine to the condenser of the main unit, a check valve being placed in the main exhaust pipe from the main unit, maintaining in this way a rarefied medium for the rotor to spin in, so that it will not overheat when running idle. The vacuum required in the exhaust end of the house turbine to prevent overheating varies with the design of the house turbine. It is only with the most efficient types of turbine that there is any danger that the vacuum which it is possible to maintain in the exhaust end of the house turbine will not be high enough during the warm summer months. The losses of such a stand-by house turbine when running in a high vacuum are very small.

It is possible to heat the condensate about 13 deg. by using the condensate to cool the air in a closed generator-cooling system; and a rise of 7 deg. more may be obtained by absorbing the heat in the transformer and turbine oil. The use of condensate in these cooling coils will keep them clean; but there is some slight complication in regard to the operation of such a system during the warm summer months, or in case of dropping of load by the main unit. This latter is probably only important in case the transformers and turbine are not paralleled as a unit on the high side of the transformers but paralleled with the other units on the low side. These transformers will stand an interruption in the cooling-water supply for several minutes without injurious effect. In studying such a system and comparing the reduction in heat requirements, consideration must be given to the fact that by absorbing this waste heat the amount of steam which can be bled from the main unit is reduced; and while there is a possible reduction in the heat requirements of the plant of $1^3/_4$ per cent by absorbing the waste heat, if additional steam is bled from the thirteenth stage of the main unit the heat requirements will be about 136 B.t.u. per net kw-hr. higher than if the condensate temperature is raised by the waste heat in the generator air and transformer and turbine oil or the net gain in station economy of absorbing this waste heat is about eight-tenths of one per cent.

SURVEY OF ENGINEERING PROGRESS

A Review of Attainment in Mechanical Engineering and Related Fields

Recent Developments in Steam-Turbine Design

Largest Single-Cylinder Single-Flow Reaction Turbine Yet Built

DESCRIPTION of a turbine built by the Westinghouse Company in which large capacity at moderate peripheral speeds and conservative stresses have been made possible by the use of the Baumann system of blading, while a symmetrically expanding steam path eliminates eddies. Certain constructional features are also described.

The great problem in a large turbine is to provide enough large blades at the exhaust end to pass steam efficiently, while centrifugal force limits the blade length and diameters to those which will not exceed safe stresses in the materials available.

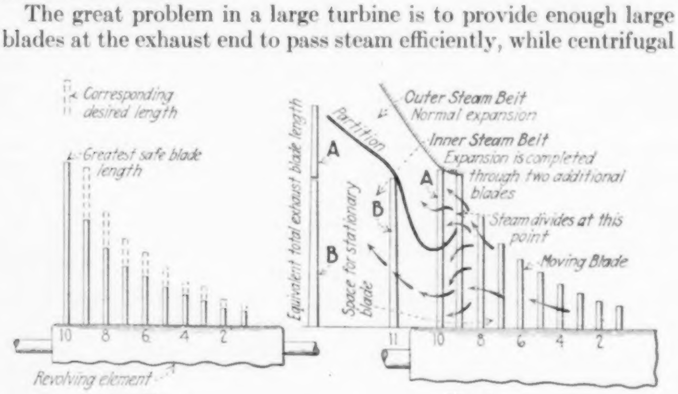

Fig. 1 Fig. 2

FIGS. 1 AND 2 BAUMANN PRINCIPLE INCREASES CAPACITY OF SINGLE-FLOW TURBINE

Designers have hit upon two ways for providing vane area for the complete expansion of the increased volume of the steam and its discharge to the condenser at a moderate velocity. One school has adhered to the single-cylinder direct-flow type, meeting the necessarily high peripheral velocities by refinements in material, design, and workmanship combined with a reduced factor of safety. Another school has attacked the problem by dividing the exhaust and providing two sets of exhaust blading, one at each end of the cylinder, making what is called the double-flow type; or by dividing the turbine into several turbine-generator units, with a high-speed, high-pressure unit exhausting into one or two lower-speed, low-pressure units. In the latter "cross-compound" type, high speed in the high-pressure unit is made possible by the relatively small high-pressure blades. This means that more work can be obtained efficiently per row of blades, since the work done per blade is approximately proportional to the square of the blade speed, and therefore less blade area is required. The slower low-pressure units are better for the employment of long vanes at the exhaust on account of lower centrifugal force at the required blade speed, and the double-flow principle is easily applied. The cross-compound unit possesses additional advantages of flexibility and reliability, but involves considerably greater first cost. Both of these expedients involve some disadvantages.

For the turbine described here, which is a 35,000-kw. unit under construction by the Westinghouse Co. for the Springdale Station of the West Penn Power Co., a method devised by Karl Baumann, of England, has been adopted.

Suppose that the largest single-flow reaction turbine, as limited by the safe length of the last row of blades, under ordinary design conditions carried 10,000 kw. at the most economical load and it is desired to increase this to 15,000 kw. at practically the same economy.

The high-pressure blades can easily be made longer so as to pass the greater volume of steam at about the same velocity, but the last row of low-pressure vanes is already of greatest safe length and cannot be extended.

Fig. 1 shows schematically such a reaction turbine, the blades in solid lines representing those for the largest single-flow machine of the usual design and dotted extensions suggesting added length for increased capacity, the proportions being only approximate. The last blade, row 10, is already of the greatest safe length and cannot be extended to A when the capacity is increased.

To pass the additional steam volume through the existing blade area in row 10 would mean increased steam velocity. Steam would then be discharged into the condenser at a high rate of speed, representing insufficient expansion and therefore lost energy that should have been used in driving the rotor.

The Baumann method of obtaining sufficient exhaust-blade area is illustrated in Fig. 2, where steam is divided into two belts at the last blade rows by means of partitions in the blades. The outer path allows expansion through ample blade area so as to do work efficiently.

Steam of the inner path is bypassed through rows 10, expanding only a small amount and doing little work. The expansion of this steam, however, is completed by adding a row of stationary and moving blades, rows 11, which contain sufficient area to use the remaining available energy efficiently and discharge into the condenser with the least practical amount of velocity remaining.

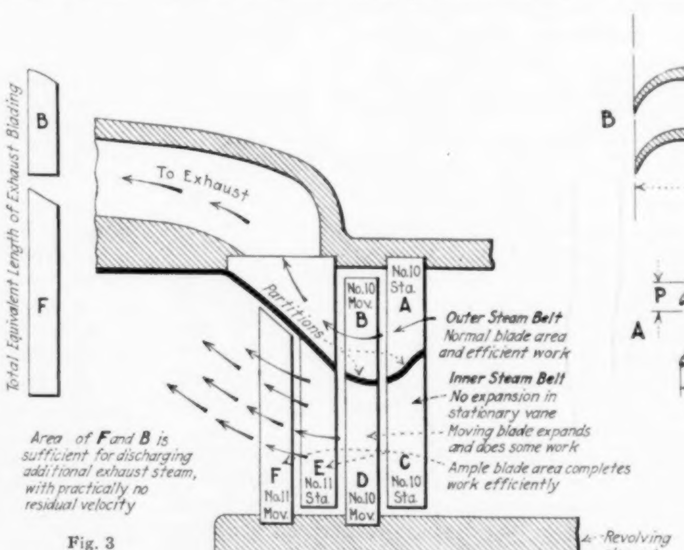

Fig. 3

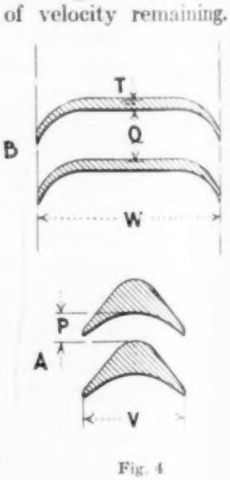

Fig. 4

FIGS. 3 AND 4 INNER BELT DOES LESS WORK PER BLADE

The combined length of exhaust blades A and B is sufficient to give the desired total exhaust-blade area without an increase in blade length.

Fig. 3 shows in more detail the construction of rows 10 of blades, as well as added rows 11. The outer belt expands normally and efficiently through sections A and B.

The inner belt separated by partitions from the outer, is bypassed

through C stationary row 10 with practically no expansion; this section acts merely as a port. Moving section D expands steam to some extent, which helps drive the reaction vanes of the rotor.

There is still a comparatively great amount of energy remaining in the steam, and this is efficiently used by adding two rows of blades, E stationary and F revolving, which are proportioned for expansion to condenser pressure with ample exhaust area. By adding one row each of revolving and stationary blades, the capacity will be increased 60 per cent above the original. In adding two rows of each type of vanes and arranging an additional steam belt the increase is 120 per cent, and with three additional rows, 170 per cent.

Another means of increasing blade area due to Baumann is by greatly enlarging the blade width at the rotor, as shown in Fig. 4. Long blades must have a comparatively heavy cross-section at the rotor, as shown at A, which limits the width of the steam passage P between blades. The same cross-sectional area used in the blades at B with greater width W, permits thinner structure and consequently a wider steam passage Q between blades. Three steam passages to exhaust are provided in the 35,000-kw. units for Springdale.

In the original article the whole blading of the turbine is shown, the Baumann construction beginning only at a certain point toward the low-pressure side. The actual conditions are such that expansion takes place in the last moving vane so that it operates on the reaction principle.

Steam enters the first blade ring at 120 lb. abs., assuming that the most economical load, 26,000 kw., is being carried. The blade rings, instead of being supported loosely in rectangular grooves in the casing, are keyed into position, so that any tendency to close in on the rotor due to abnormal conditions is restrained by the resistance of the outer cylinder.

The rotor is of forged steel and a pressed fit reinforced by bolts unites the high-pressure with the low-pressure end. To make the rotor adaptable to high temperature the joint is located where there is very little difference of temperature, and the higher temperature if any is effective on the interior member of this pressed fit which would tend to hold it tight in case it became warmer than the recessed member of the fit.

The form of rotating and stationary packing employed is described and illustrated in the original article. In this the rotating element is finished in a number of conical surfaces, while the stationary member contains thin brass annular rings or fins which project very close to the rotating body. Clearances are adjusted by moving the rotating body in an axial direction. If rubbing should occur the conical elements will radiate heat much more rapidly than the old type of ring of cylindrical shape, and there is less liability of stripping than would occur in case thin fins were used in both the moving and stationary elements.

Numerous other features are described in the original article. Of these may be mentioned the emergency governor, which, in accordance with the recent tendencies in design, is of a type that will reset itself automatically while the turbine is running, thus avoiding the excessive slowing down for resetting that was necessary with the older type. In this case the governor includes means for checking approximately whether it operates at the correct speed.

The guaranteed steam consumption of this unit at 300 lb. 650 deg. fahr. steam at the throttle, with a vacuum of 29 in. of mercury, is as follows:

Load, kw	1,750	26,250	35,000
Lb. per kw-hr	10.30	9.75	10.15

At the most economical load of 26,000 kw. the following amounts of steam are to be extracted:

High-temperature heater, 12.9 lb. sq. in. abs.: 16,380 lb. per hour.
Low-temperature heater, 3.20 lb. sq. in. abs.: 12,910 lb. per hour.
(*Power*, vol. 57, no. 20, May 15, 1923, pp. 746–752, 14 figs., *dA*)

5000-Kw. Brush-Ljungström Steam Turbine

The first public description of the Ljungström steam turbine appeared in *Engineering* of April 12, 1912. Since then it has been successfully introduced in many places. As is well known, the particular feature of this turbine is that the fixed casing and single rotor of an ordinary turbine are replaced by two rotors turning in opposite directions.

The original 1000-kw. unit was soon followed by larger units until the size of 5000 to 7000-kw. was reached in 1916. These turbines were designed, however, to work with a vacuum not exceeding 28 in., and when with the development of condensing apparatus a vacuum of 29.1 in. was commercially reached, the Ljungström turbine had to encounter the same difficulty as all other turbines, namely, producing a steam path sufficiently ample to reduce "leaving losses" to a reasonable percentage. In the Ljungström turbine this problem was solved by fitting radial blades to the periphery of the Ljungström rotors.

The essential features of the construction of the turbine may be seen from Fig. 5 showing the upper half. The two steam rotors are denoted by h and h^1, respectively. The steam enters between the rotors near the center and flows radially to their circumference passing through the blading shown. This blading was described in detail in a previous article, as also the methods used in its manufacture, so it is not necessary to refer to it more particularly here.

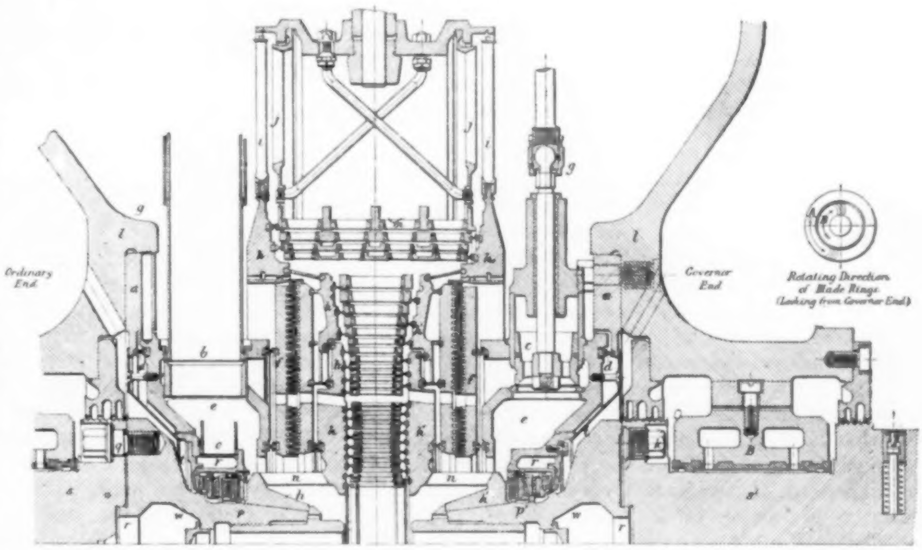

Fig. 5 Section through the Upper Half of the Brush-Ljungstrom Steam Turbine Showing the Direction of Rotation and Blade Rings

The original Ljungström turbine terminated in the row of blades lettered m, but with the high vacuums now specified it was impracticable to make such blading long enough to provide the requisite steam way. Hence, in the new model, after leaving m, the steam is passed through the fixed guide blades j, which direct it on to impulse blading i, which is, it will be seen, mounted radially on the periphery of the rotors. This last stage of the turbine provides, it will be seen, a "double flow," giving an ample steam way and moderate "leaving losses," the axial velocity of the steam on leaving the last row of blades being from 500 to 550 ft. per sec. The steam chest e is machined out of a solid steel forging and is carried from the flanges a, a by means of the dumb-bell expansion rings shown at d,d. These enable the components to adjust themselves, without heavy strain to changes of temperature. Similar dumb-bell rings connect to the steam chests e,e, the stationery labyrinth disks f,f, which form one-half of the dummies which prevent serious leakage from the steam chest to the exhaust space g. These dummies were fully described in previous articles, to which reference has already been made.

Each of the rotors h and h^1 is built up of three main components exclusive of the labyrinth disks. These three sections are also connected to each other by dumb-bell expansion rings. The innermost section of each rotor fits on to a conical seat p or p^1,

which can be bolted to the corresponding generator shaft s or s^1 by a ring of bolts one of which is shown to the left at q.

At the corresponding position on the opposite side of Fig. 5 is shown a starting bolt k which, when the turbine is to be dismantled, is used to bring out of their recesses the registers at r or r^1. In effecting this operation, the rotor of one of the generators is displaced for a short distance axially. The flanges a,a are, of course, free once the top cover has been removed, and once the registers are clear, the whole of the turbine can be lifted out of place as the steam-pipe joints are merely telescopic. Special tackle is provided for this operation which will be discussed later.

Steam from the steam chest e gets access to the blading through a series of openings n,n machined in the innermost sections of the rotors. In passing between the rotors, the steam produces a heavy axial thrust on each, and this thrust is balanced by the counter pressure of the steam which is simultaneously leaking through the dummies f. Any residual thrust is carried by Michell thrust bearings. As originally constructed, oil-filled dashpots were provided for this purpose, but while quite effective, they required careful attention to prevent leakage of oil or the entrance of air.

The glands w,w, where the rotor shafts pass through the fixed steam chest, have to be packed against high pressures. The escaping steam, as it leaves the last constriction of the gland, is caused to draw in air, by an ejector action, from the spaces t,t; and to discharge it into the spaces r,r, which are connected by pipes, one of which is indicated at o. This pipe leads away the mixture of steam and air to a separate condenser. The object of this arrangement is to prevent the possibility of steam leaking into the space t, where it might condense and fall into the oil, while further steam might pass beyond the bearings to the generator windings.

Owing to the gland steam being thus diluted with a large admixture of air, it cannot be turned into the main condenser, and a small auxiliary condenser has to be provided accordingly. The main condensate from the turbine passes through the tubes of this condenser, thus recovering the heat from the gland steam. Repeated measurements have shown that this gland leakage amounts to from $^3/_4$ per cent to 1 per cent of the total steam passing through the blades.

The turbine is governed by throttling the supply to a small servo-motor arranged above the steam stop valve. The piston of this motor is spring-loaded, and the stop and governor valves are opened by forcing oil below this piston so as to raise it against the pressure of the spring. The valve opening depends upon the height to which the piston is raised, and this depends, in its turn, on the pressure of the oil admitted below it.

A noticeable point in this governor is that no dashpot is provided to stop hunting, as it has been found unnecessary if friction be adequately eliminated. To this end ball bearings have been freely employed and very ample and complete lubrication provided for. The builders state that this is so effective that in certain cases the rise in speed between full load and no load has been under 1 per cent. In addition to this, emergency governors described in the original article are fitted into the generator shafts.

The original article also describes the many interesting details of the installation, such as the construction of the main bearings, details of the Michell thrust bearings, overload valve, steam glands, oil cooler, the special tackle used for lifting the turbine in and out of place, and the air pump—which is really a Brush-Delas ejector, as well as the generator driven by the turbine. No data of tests are presented. (*Engineering*, vol. 115, no. 2992 and 2993, May 4 and 11, 1923, pp. 542–545 and 577–578 and 2 plates of drawings, illustrated, *dA*)

Hardness and Hardness Testing

The Quality of Hardness

TO FIND OUT exactly what hardness is and to state its measure in the fundamental units is a work of pure science which no one seems yet to have attempted. The first step in the process is for some physicist with insight, a type of man which this country fortunately produces fairly frequently, to frame a hypothesis based on what is known of molecular physics, and consistent with the various phenomena of hardness. The confirmation of the theory, by experimental verification of the conclusions which logically follow it, is a matter for the commonplace type of careful research worker, and can be carried out in any physical laboratory provided with the necessary equipment. The absence of any theory of what constitutes hardness is significant of the complexity of the characteristic of materials which is denoted by the term. The hardness of ivory is different from the hardness of lead, and this again is different from that of india rubber, yet any definition of hardness which is to be as scientifically precise as that of temperature, density, or elasticity, for example, must be applicable equally to all substances.

Several ways of testing hardness depending on different variables have been devised. If all these tests are true measures of hardness, it follows logically that there must be some consistent relationship between them so that their indications are convertible into the same scale of hardness. A vast amount of labor has been expended in the endeavor to establish mutual relationships between many of them, but with little real success.

Special attention is called to the scratch test described in a paper presented to the Institution of Mechanical Engineers recently. This test, like others, will no doubt have its uses in a particular field, but the field is likely to be a very limited one. Even if diamonds ground to standard angles could be commercially obtained, and a reliable scratching instrument could be devised, the measurement of the width of the scratches to the accuracy required by means of a high-power microscope is not for the ordinary workshop.

Exactly what property of the material the scratch test measures is by no means clear, but this is a defect common to all the other hardness tests. It has nothing in common with the old mineralogical hardness test which graded a material according to whether it would scratch or be scratched by any member of a series of standard materials. The point of a diamond will, of course, scratch anything, so that there is nothing comparative about the diamond scratch test except the size of the scratches a standard diamond will make under standard conditions. The first diamond point used in the experiments at the National Physical Laboratory was something like a blunt inverted pyramid, and, as might have been expected, the scratches were too ragged for accurate measurement to be made. They were, indeed, real scratches in the ordinary sense of the word. The next diamond tried was shaped something like a screw-cutting tool for cutting brass, but, again, as might have been foreseen, its action was to cut rather than to scratch the metal, and it "dug in" and cut wider and wider, exactly as a lathe tool would do under similar conditions. Finally, the diamond was reversed and the metal was dragged under it in the reverse direction, and under these conditions V-shaped grooves were pressed in the test piece. It is the widths of these grooves, which are of microscopic dimensions, which it was the object of the research to correlate with the hardness of the material.

Until our physicists have come to some agreement as to what property of the molecules of a substance, or what configuration of these molecules gives the quality to a material which we connote by hardness, the subject will never be put on a really scientific basis. There are enough and to spare of so-called "hardness tests," and nothing is to be gained by devising any more. If a certain Brinell number, scleroscope number, or scratch width is found to be associated with the quality of material which is satisfactory for a certain purpose, then the particular number or width can be used as an acceptance test for the material. This, in fact, is what is done in practice, and further than this the engineer cannot go at present. In spite of all the efforts which have been made to justify the several tests by scientific considerations they still remain empirical determinations of an unknown quantity. If hardness is wanted in a material for the resistance of abrasion, the amount of abrasion produced under given conditions is the only true measure of the kind of hardness required. If penetration is to be resisted, as in the case of armor plate, some kind of penetra-

tion or indentation test is obviously suggested. If, on the other hand, hardness is taken as an indication of tensile strength, or of chemical composition, it is surely better, whenever possible, to determine these characteristics directly. The ease by which certain so-called tests of hardness can be applied to finished material without injuring it, and the pseudo-quantitative nature of the numerical results obtained, tend, by reason of their attractiveness, to disguise the fact that it is an unknown quantity which is being measured, and one which may, or may not, be correlated with the characteristics desired.

The conclusion to which the author arrives is that the accumulation of the results of hardness tests of numerous kinds is now so vast that it seems that the time has come for the physicist to step in, and that the invention of further hardness tests and the collection of additional uncorrelated data are to be deprecated until some agreement can be arrived at as to the exact property of the tested material which is in question. (Editorial in *Engineering*, vol. 115, no. 2991, Apr. 27, 1923, pp. 527–528, *gA*)

Relation Between Width of Scratch and Load on Diamond in the Scratch Hardness Tests

By G. A. Hankins

Experiments described in the present paper have been carried out by the National Physical Laboratory for the Hardness Tests Research Committee of the Institution. The work was suggested originally by Dr. Unwin, who considered that the relation between the width of the scratch and the hardness number required further investigation.

The apparatus used for the tests is described. Of particular interest is the description of the various types of diamonds used for the test, as the type employed appears to affect the results to quite a material extent.

The results obtained show that with the materials used a straight-line law exists between the square of the width of the scratch and the load on the diamond, and that with each diamond under constant conditions the straight lines appear to meet at the same point for all materials. Taking p and q as the coördinates of this point, it appears that a law exists of the form:

$$(P-p) = k(w^2-q)$$

where P = load on diamond, w = width of scratch, and k = a constant for each material. Hence

$$k = \frac{P-p}{w^2-q}$$

k will thus be a stress, and it is suggested that the values of k for different materials may be taken as a measure for the hardness of the materials as determined by the scratch method.

Scratch hardness as thus defined has been plotted against the apparent Brinell hardness. The actual values of k appear to be dependent on the shape of the diamond and the angle with the test surface, but the type of curve is the same in all cases. The ratios of the scratch hardness to the Brinell hardness numbers have been calculated and are given in a table in the original article, from which it appears that a minimum value occurs at a Brinell hardness of about 450. With the exception of the value for copper, a progressive increase in the ratio occurs for both higher and lower values of the Brinell numbers. The manner in which the diamond has been used in the present tests appears to give a scratch which is of the nature of an indentation test on the materials, and therefore agreement with the Brinell numbers might be expected. The variations in the ratios seem too uniform to be due to experimental errors, and it appears that the test does measure a property of the material slightly different from that measured by the Brinell test. The value of the ratio found for copper is interesting when considered in connection with Professor Turner's statement, that "a piece of hard-rolled copper may give a greater hardness number than one of mild steel, yet a tool made of mild steel will always cut copper and no amount of cold rolling will make copper cut steel."

The results show that the method can be utilized to obtain a measure of the hardness of metals on the same scale over a very wide range, but at present the most useful applications would appear to be in the case of the harder materials or where only small or valuable specimens are available. For general use it seems that a standard shape of diamond would have to be adopted, since the results obtained depend on the shape of the diamond, but comparison of the results obtained with two of the diamonds used appears to show that small variations in the angles of different diamonds do not have a large effect on the results obtained. (Paper read before The Institution of Mechanical Engineers, Apr. 20, 1923, abstracted through *Engineering*, vol. 115, no. 2991, Apr. 27, 1923, pp. 537–540, 17 figs., *et*)

Static Indentation Tests

By R. G. C. Batson

This paper contains the results of various investigations which have been carried out for, and reported to, the Hardness Tests Research Committee for the Institution of Mechanical Engineers during the years 1919–1922, with a view to elucidating various points in connection with the application of indentation test as a measure of the hardness of materials. The points considered are as follows: (1) Investigation of law of comparison for ball indentation tests; (2) a comparison of the ball and cone methods of test; and (3) the determination of the relative hardness of very hard steels by means of ball hardness tests, in which the permanent deformation of the ball is taken as a measure of the hardness of the material producing it.

Among other things, the author compares results obtained by the employment of the cone pressure test such as is used on the Continent with those obtained with the standard ball method. For this purpose a series of tests has been carried out on four materials to compare the hardness numbers obtained by using a 10-mm. diameter ball and a 90-deg. cone, when these numbers are in each case calculated from (1) the diameter of the impressions as obtained by a measuring microscope after the test, and (2) the depth of the impressions when the pressure has been removed, measured from the original surface of the materials.

From these tests it would appear that

1 The hardness numbers obtained with a 10-mm. ball and calculated from the diameters of the impressions are not independent of the load. This fact is well known and has been pointed out by many experimenters.

2 When the depth of the ball indentation (from the original surface) is used for calculating the hardness numbers, the numbers obtained are independent of the load within the range of these experiments. This fact was pointed out by R. P. Devries in 1911 (U. S. Bureau of Standards Technologic Paper No. 11).

3 With the cone test the experiments made for the purpose of the present paper appear to show an effect of the opposite kind from that described under conclusions (1) and (2) for the ball test. The hardness numbers calculated from the diameters of the impression (using the conical area of the impression as recommended by Ludwik) are approximately constant, and those obtained from the depth of the identation vary with the load.

4 It follows from conclusions (1), (2), and (3) that with varying loads the complete impressions with the ball test are dissimilar, and with the cone test are similar. It also follows that, when the part of the impression caused by the "ridge" is neglected, the impression under varying loads given by the ball test are similar and by the cone test are dissimilar.

5 The hardness numbers with a load of 3000 kg. show that, whereas for three of the materials the ratio is approximately the same, for manganese steel the cone test gives a much higher relative result than the ball test. For this reason it is not possible to give a definite ratio under these conditions between ball-test results and cone-test results for all materials.

It will be noticed that for the three materials and with the methods of calculation adopted, the ball test gives numbers which are from 8 per cent to 13 per cent higher than the cone-test numbers when using the diameter of the indentation, and 3 per cent to 9 per cent lower when using the depth of indentation from the original surface of the test piece. It was suggested that in order to obtain the same hardness number for both ball and cone tests, the hardness number should be taken as equal to

$$\frac{\text{Load}}{\text{projected area of indentation}} = \frac{L}{\pi d^2}$$

where L = load and d = diameter of the indentation. By adopting this method of calculation the cone hardness numbers would be 41.4 per cent higher and the ball hardness numbers less than 12 per cent higher (this depending on the diameter of the indentation) than those obtained by the method previously described. There would thus be a still greater difference between the cone- and ball-hardness test numbers if this method of calculation was used. (Paper read before the Institution of Mechanical Engineers, Apr. 20, 1923, abstracted through *Engineering*, vol. 115, no. 2991, Apr. 27, 1923, pp. 534–537, 10 figs., *et*)

Short Abstracts of the Month

AERONAUTICS

Cycle Engines for Light Planes. Description of the Bradshaw 500-cc. oil-cooled engine. The main feature of this engine is that with the exception of the cylinder heads it is cooled by the lubricating oil, which is in turn cooled by radiation from the walls of the crankcase, which is therefore made of particularly large proportions.

Owing to the fact that the oil is used for cooling as well as for lubrication, the lubrication arrangement is naturally somewhat unusual. Driven from the camshaft is a gear pump, which draws oil from the sump in the crankcase through a large gauze filter, and delivers it under pressure to the internally drilled crankshaft. By a special system of oil-release grooves the flow of oil through the crankshaft and from the big ends has been increased by 100 per cent, so as to give cooling as well as lubrication. From the big ends the oil is splashed on to the cylinder walls, the inside of the pistons, to the valve gear, etc., and it is claimed that the whole oiling system requires no attention.

The engine, which is a flat-twin, is rated to develop in the neighborhood of 11 b.hp. at 2500 to 3000 r.p.m. and for this power weighs approximately 70 lb. in full running order, or about 46 lb. without flywheel, magneto and carburetor. (*Flight*, vol. 15, no. 18/749, May 3, 1923, pp. 240–241, 3 figs., *d*)

Jet Propulsion for Aeroplanes

Jet Propulsion for Airplanes, Edgar Buckingham. Data of work undertaken at the Bureau of Standards on the request of the Engineering Division, Air Service, U. S. Army, and later submitted with their approval to the National Advisory Committee for Aeronautics.

The term "jet propulsion" as commonly understood implies the use of a small intense jet maintained by some other means than an airscrew. Thus, if air is compressed and mixed with fuel in a combustion chamber where the mixture burns at constant pressure, and the combustion products issue through a nozzle, the reaction of the jet constitutes the thrust.

Only the simple nozzle such as is used in steam turbines is considered in the present investigation, which did not cover in detail the possibility of improving the propulsive efficiency of the jet by any of the aspirator or ejector devices that have been proposed for increasing the momentum and thrust.

Data are now available for an approximate comparison of the performance of a jet propulsion device with that of the motor-driven airscrew.

The conclusions at which the author arrives are not in favor of propulsion by the reaction of a simple jet, which he claims cannot compete in any respect with airscrew propulsion at such flying speeds as are now in prospect.

While the relative fuel consumption and weight of machinery for the jet increases as the flying speed increases, still even at 250 m.p.h. the jet would take about four times as much fuel per thrust horsepower-hour as the airscrew, and the power plant would be heavier, much more complicated, and also more delicate.

To say nothing of the fuel-injection system, the combined compressor and engine would have about twice as many pistons, valves, and other moving parts as a simple engine, and the chances of breakdown and the difficulties of upkeep would be correspondingly increased.

There are, to be sure, a few obvious advantages in the jet scheme. The large, awkward, and fragile propeller would be eliminated, and only the nozzle and not the engine would have to be located with regard to the axis of thrust. Thus the design would be more flexible. The machine might also, if strong enough, be given brilliant maneuvering powers by utilizing the powerful steering effect of swinging the nozzle. On the other hand, a machine which had to start, if it could get off the ground at all, by emitting a jet of flame at 2500 deg. fahr. and a speed of one mile a second would hardly be a welcome visitor at flying fields.

The only hope of success lies in the use of thrust augmenters which are devices or arrangements that will increase the momentum of a jet already formed without increasing the fuel consumption needed for maintaining the jet or adding seriously to the weight. Devices of this sort have been proposed and the author discusses them qualitatively. These devices consist mainly in surrounding the jet after it has left the nozzle by a series of ring-shaped guides, of curved profile, after the manner of an ejector or aspirator. If these guides are properly designed, the pressure in the internal free space about the jet falls below atmospheric, air is drawn in, and before it comes into actual contact with the jet, it has already, in its passage through the curved ports between the guides, acquired a considerable component of velocity in the same direction as the jet. The idea seems to be that the shock loss will be reduced and kinetic energy saved; that the backward momentum of the entering air will be added to that already present in the jet so as to increase the thrust; and that the thrust horsepower of the whole combination will be augmented, without any modification of the part of the apparatus originally provided for maintaining the jet or any increase of fuel consumption.

It is hard to see just how this sort of process can be analyzed and referred to the elementary principles of mechanics and thermodynamics so as to permit of forming any definite quantitative opinion of its feasibility. There is no doubt that ejectors and aspirators built on this plant have been very useful and effective for certain purposes; but whether, in the application now in question, they would have the effect hoped for seems very problematical, and the present writer remains skeptical. (*National Advisory Committee for Aeronautics*, Report no. 159, 1923, 18 pp., 7 figs., *et*)

Gyroscopes in Aircraft Instruments—Gray Stabilizer

On the Application of the Gyroscope to the Solution of the "Vertical" Problem on Aircraft, Prof. James Gordon Gray and Capt. J. Gray. Description of various devices, chiefly those developed from research work carried out in the Natural Philosophy Institute of the University of Glasgow, where the first of the authors is Cargill Professor of Applied Physics. These devices relate to apparatus for finding, maintaining, and thus defining the true vertical and horizontal on aeroplanes and airships. The so-called "vertical" problem and with it the application of the gyroscope is of importance. Navigation must be made precise by the provision of gyroscopic sextants; photography from airplanes to be accurate must be carried out by means of special cameras stabilized so that the photographs are true vertical productions; bombing from airplanes must be rendered accurate by designing the bombsight as part of an accurate stabilizer, etc.

The article is very extensive and can be abstracted only very briefly. Among the interesting portions which cannot be abstracted is a discussion of the behavior of a gyroscopic pendulum when it is mounted on an airplane which moves in a curved path. The authors derive the equations determining such behavior. From this it would appear that if the spin of the gyroscope is clockwise as seen from above, and the airplane moves round in the counter-clockwise direction as also seen from above, there will be a growing deflection of the pivoted system with respect to the vertical. In general, they come to the conclusion that if the gyroscopic pendulum is to meet with success it must have a real periodic time of precessional motion or virtual periodic time in the presence of curvilinear motion on the part of the airplane which is upward

of one hour. This would make pendulums which have a periodic time in excess of only 4 min. useless, notwithstanding the fact that such pendulums have been highly endorsed.

Furthermore, under the conditions which prevail on aircraft, gyroscopic pendulums which depend for their action on gravity control and dashpots are of little or no use; under such conditions these devices leave the vertical quickly and return very slowly.

The gyroscopic pendulum of the type in which the erecting action depends on the existence of precessional motion, is subject to an error due to the rotation of the earth when supported on a steady platform at rest. But if it is carried on a moving vehicle, such as an airplane, the errors due to the motion of the vehicle are so large that it is unnecessary to consider those due to the earth's rotation.

From this the paper proceeds to the description of the Gray stabilizer. It consists of a gyroscopic system pivoted in the conventional manner and having the following properties. Should the pivoted system be inclined to the vertical during normal flight of the airplane or airship, a stabilizing couple is applied to the gyroscope and the device is restored to the vertical. The stabilizing couple is obtained by means of a special erecting device, and depends in no way on precession of the gyroscope in the ordinary sense of the term. During curved flight of the airplane the erecting device goes automatically out of action. Thus the pivoted system leaves the true vertical very slowly, if at all, in the presence of curved flight, and approaches it relatively quickly during normal flight.

The various designs of this stabilizer are described in great detail. Experiments carried out by means of the sun-shadow methods (described in the original article) are claimed to have shown that these stabilizers remain absolutely undisturbed by the pitching and rolling motions of an airplane.

The authors recommend using powerful gyroscopes for airplanes with their stabilizers, such as, for example, those having an angular momentum of 2000 in ft-lb-sec. units. This is the angular momentum possessed by a whirl of mass 20 lb., radius of gyration 3 in., when performing 250 r.p.s. Complete with its casing and bearings such a gyroscope would have a mass of about 25 lb. and the diameter of its casing would lie between 7 and 8 in. For use on board ships of war in connection with anti-aircraft devices, much larger gyroscopes are recommended such as those having an angular momentum upward of 5000 in. ft-lb-sec. units.

An interesting feature claimed for the Gray stabilizer is that it is free of error due to rotation of earth. (*Proceedings of the Royal Society of Edinburgh*, vol. 42, no. 3, pp. 257–317, 38 figs., *tdA*)

AIR MACHINERY (See also Aeronautics)

Surface Air Coolers

Physical Consideration and Design of Surface Air Coolers. A. R. Smith. This article forms a part of a series under the general title of Cooling of Turbine Generators and deals with the details of design of surface air coolers.

The size of tube now used is $^5/_8$ in. outside diameter, 18 B.W.G. wall, and made of either muntz metal or Admiralty brass. While larger tubes may be used, it would appear that they do not present any important advantages.

In order to give the maximum amount of cooling surface at the minimum expense, the tubes are wound with copper fins spaced seven to the inch and having an effective depth of $^1/_4$ in. The addition of fins increases the external radiating surface of the tube, which is the high-resistance side, over six times. The fins are shouldered and soldered to the tube so that the joint presents no resistance to the flow of heat. They are flat and smooth.

The tube sheets are made of rolled muntz metal, which gives a non-porous tube sheet, and this prevents water from seeping through into the air space.

Over each of the tube sheets are bolted by means of studs and nuts cast-iron water boxes, provided with a large inlet and outlet to reduce turbulence, which would tend to affect the distribution of water through the tubes. The coolers are arranged so that the tube sheets form a part of the air duct, which leaves the water boxes accessible so that the tubes can be inspected or cleaned with the least possible inconvenience.

The plan so far has been to maintain a minimum water velocity through the tubes which would be in excess of the critical velocity. The maximum water velocity naturally depends on the pumping head permissible. The number of water passes depends on the number of tubes in the cooler and on whether condensate or circulating water is used. Eventually, the number of water passes will probably become more or less standard because the conditions under which turbine generators operate are not very different. For the present, however, any number of water passes can be obtained to meet conditions.

The flow of water with respect to the flow of air is countercurrent.

The resistance to the flow of air through the cooler is dependent on the air velocity and the depth of the cooler, the temperature of the air having only a slight effect on the drop in air pressure through the cooler. If a fixed amount of surface is so distributed that the air velocity is low, the depth of the cooler will naturally be reduced; but the same amount of surface can be so distributed that the depth is considerably greater, which will result in a higher air velocity. When an approximation of the amount of surface is made, it is obvious that it can be so arranged, provided there is sufficient space, to obtain almost any resistance that may be desired.

Resistance to the flow of air in large air ducts of moderate lengths is almost a negligible factor. Excessive pressure drops are the result of eddying and loss of velocity heads. In laying out any duct system, and especially those in connection with surface coolers, where all of the available pressure loss should be applied to the cooler, the ducts should be carefully designed and in many cases can be so designed that the duct loss can almost be neglected.

The loss of head or resistance to the flow of water is also a variable quantity, and there is considerable latitude in regulating the total pressure drop. A velocity in the tubes of not less than 2 ft. per sec. is desired so as to keep the flow above the critical velocity. If a velocity of 5 or 6 ft. per sec. is attempted, the number of water passes are increased and the friction head increases very rapidly.

Where the coolers utilize the condensate as a circulating medium, then a relatively high velocity, say, of 4 or $4^1/_2$ ft., is desirable when the turbine is operating at full load, so that at partial loads the velocity is more nearly normal. The total pressure drop in the cooler from the inlet to the outlet nozzle usually runs in the neighborhood of 20 ft.

In most cases the surface cooler presents a number of economical and operating advantages. To what extent these advantages may be capitalized depends of course upon local conditions. The common advantages are as follows:

1 If the air-duct system contains but a small volume of air, no fire extinguisher should be necessary because the oxygen will be rapidly consumed and the fire smothered without requiring the attention of an operator, or the operation of any dampers.

2 If the proper precautions are taken to prevent any material infiltration of air, the deposits in the machine or on the cooler should be insignificant. If a clean generator is maintained, the temperature rise of the winding above the incoming air temperature should not increase with age.

3 The volume of water required for cooling the air can be regulated because the flow of water is counter-current with respect to the flow of air. Where water is expensive it is therefore possible to economize on the quantity.

4 The pumping head or the amount of auxiliary power required is extremely low.

5 Where condensate can be employed either wholly or in part, for the cooling of a generator, some or all of the generator losses are returned to the system in the form of heat.

There may be arrangements adopted where the puncture of a tube might release water into the generator. Such a condition can be guarded against by the installation of water eliminators which have been developed especially for such a purpose. The employment of eliminators, however, will introduce additional friction in the air circuit and it is recommended that the coolers be so located as to avoid the necessity of using eliminators. With the cooler sections located below the generator the spouting velocities of the water may prevent it from entering the generator winding even though it is assumed that such a leak develop at just the right point on the upper row of tubes. (*General Electric Review*, vol. 26, no. 5, May, 1923, pp. 298–303, 5 figs., *d*)

ENGINEERING MATERIALS

New Bearing Metal—Thermit. Data of a new metal developed by Professor von Hanffstengel together with the Th. Goldschmidt Co. in Essen. The exact composition of the new metal is not given. It is stated, however, that it belongs to the class of materials containing lead, in addition to which it has other ingredients. Its properties depend essentially on correct alloying and mixing practice, and it is stated that it gives better results than certain other bearing metals used in machinery when it so happens that the bearings fail to receive proper lubrication. (*Technische Blaetter*, published weekly by the Deutsche Bergwerks-Zeitung, vol. 13, no. 16, Apr. 21, 1923, pp. 113–114, 4 figs., *d*)

Coronium Bronze Alloy. The precise composition and process of manufacture of the alloy is not given, but it is stated that it contains copper, 16 parts; zinc, 3 parts; and tin, 1 part, which figures include the usual impurities.

With regard to physical properties, in ordinary sand castings of handy size, tensile tests have given 16 to 18 tons per sq. in., according to conditions connected with each case. In some cases where very special castings have been made and unusual precautions taken in the pouring and cooling, an ultimate tensile test of 22 tons per sq. in. has been officially reported. In one of the cases last referred to, the elongation was officially given as 38 per cent on 2 in., this having reference to the same test piece, and at the same time there was a reduction of area observed of 37 per cent. The elastic ratio observed at the same time was 0.6, a figure of great importance. Referring again to the figure of from 16 to 18 tons per sq. in., engineers using the material for commercial purposes can safely rely upon an elongation taken on the same test piece having a figure in excess of 25 per cent in 2 in., with a reduction of area in excess of 25 per cent at the same time. The Brinell hardness as cast may be taken under any circumstances at a figure of 85 to 90 on the Brinell scale, and the machinability—assuming good brass to be 80—at 100.

The metal can be rolled cold into sheet of the finest gages, and drawn into rods or tubes and generally wrought with ease. The effect on the physical properties of rolling into rod is a good general example of the result of mechanical treatment, and the tests that have been made gave very interesting results. Test pieces were taken from a bar rolled from the ingot to $^5/_8$ in. in diameter, and the maximum tensile stress was proved to be over 35 tons per sq. in., with a corresponding elongation in 2 in. of 58 per cent and a reduction of area of just over 60 per cent. The specific gravity in the cast state is 8.9, as compared with 8.8 as the maximum figure obtained in the heaviest phosphor bronze as cast. The melting point is 1100 deg. cent. (2030 deg. fahr.). The strength and elastic limit are not seriously affected by annealing. Compared with phosphor bronze, the latent heat is greater, and the heat conductivity correspondingly rather less. The alloy has an electric resistance as great as that of nickel (whose resistance is materially higher than that of any copper alloy). The power of resistance to corrosion, so far as it has been possible to test the matter, seems to be very high. The coefficient of expansion has not been finally determined, but observations up to date show that it corresponds very closely to that of cast iron. (*Foundry Trade Journal*, vol. 27, no. 350, May 3, 1923, pp. 359, *d*)

Centrifugally Made Concrete Poles

Concrete Poles Made by Centrifugal Process. Reinforced-concrete poles made by centrifugal process are receiving considerable attention these days, particularly in Europe.

One of the largest power-transmission lines in Sweden is carried by means of such poles. These carry two cables between the poles, which are about 36 ft. apart, and two at the ends of the cross-beam, which is about 54 ft. in length. According to the changing local conditions along the line and the variations in the load from 1200 to 1400 lb., four different sizes of poles were made which were from 56 to 59 ft. in height, from 9 to 10 in. in diameter at the top, and from 18.5 to 23 in. at the bottom. The average wall thickness is 2 in. Nearly 6 per cent of them were tested, and some—about 1 per cent of the whole number—were subjected to bending stresses till fracture occurred.

It was stipulated that the latter had to withstand at least four times the highest ultimate load at the top. The others had to be subjected to double that load without showing any cracks or alterations of form. The tests proved, however, that the poles were exceedingly elastic and could carry six to eight times the highest ultimate top load. During the tests the load was taken off several times, and the top went almost completely back into its original position, showing that the bending was of an entirely elastic nature. Even after fracture had occurred the steel reinforcement was still able to stand considerable stress as it had only slightly been damaged. In some cases when the breaking stress had been reached, cracks from the tensile stress outside the bend and signs of excessive pressure inside the bend appeared at the same time, which shows that the tensile stress which centrifugal concrete will stand is considerably above the usual normal for concrete. Some of the poles, 64 ft. long, being subjected to a bending stress of 7300 lb. bent $7^1/_2$ ft. at the top without any signs of damage. The poles were tested at an age of six to seven weeks. It had also been proved that their earth connection, which was brought about by attaching contact pieces to the steel reinforcement, was good, and that the electric resistance was less than 0.2 ohm.

These poles are manufactured in a wooden mold which is revolved in a special machine. This mold consists of two half-round forms, and is lined with sheet iron inside. The reinforcement is formed by rolled rods, of open-hearth material, going lengthwise, which are interwoven with three spirals of wire one within the other. It is wound upon a special automatic machine, so that the uniformity in their measurements and the strength of the poles is insured. The spirals influence the fracture stress comparatively little but they determine to a certain extent the rigidity of the pole, and by using three spirals it has been possible to reduce the bending to 0.5 per cent of the length at the normal load, and to 1.5 per cent at the double load. In order to give the maximum strength to the pole, care is taken that the reinforcement comes as close as possible to the circumference and is at an equal distance away from it. The cement mortar is mixed in proportion of one to three, and some asbestos fiber is added to assist in holding the sand and cement together.

After the wire structure and the cement have been put into the mold, it is closed and put into the machine. According to the diameter of the pole, the mold is then revolved at a speed of 500 to 1000 r.p.m. This high velocity, which is attained immediately after starting, and continued revolution at the same speed are necessary to prevent a decomposition of the mortar, which would take place on account of the different specific gravities of sand and cement. The excessive water in the mortar accumulates in the hole in the center, and in striking the wall of the pole during the rotation, increases the compactness of the grain. The fears that the cement would be thrown to the outside and that the mixture would become less rich toward the center have been proved unfounded.

The centrifugal arrangement consists of several machines which are lined up one behind the other. Each machine has two strong side frames with a large center bore. Inserted in the bore is a tube which rolls freely between six wheels carried by three shafts which may be adjusted radially in relation to the bore. The tube is fitted with a self-centering chuck for holding the wooden mold. All machines are driven from a main shaft, the center tube serving as a pulley. After revolving the mold in the machines for about 10 to 15 min. it is taken out, the lid at the end is removed, and the water is poured out of the center. The pole is left in the mold for 1 or 2 days. It has then set sufficiently to be taken out, and is kept in moist sand for about 3 to 4 weeks. (*Power Plant Engineering*, vol. 27, no. 10, May 15, 1923, pp. 531–532, 2 figs., *d*)

HYDRAULICS

The 40,000-Kva. Shawinigan Falls Water-Wheel Generator, J. Ralph Johnson. Description of a generator installed in a Canadian plant and notable not only on account of its size but also for certain features of design of the most modern character. It has been in operation since October, 1922, and is a unit of the vertical type with direct-connected exciter designed to deliver normally 40,000 kva. of three-phase current at 0.75 power factor,

60 cycles, and 11,000 volts while running at a speed of 138.5 r.p.m. It is, however, capable of working at considerable overloads and overvoltages for limited periods of time.

Only the mechanical features of design will be primarily reported in this abstract, although the article contains also the description of several interesting electrical features.

In this installation the operating floor is level with the top of the stator frame. This construction gives ample space round the generator on the main floor and provides a convenient means for dealing with the exhaust air from the generator in the annular space beneath this floor. The air may either be utilized to heat the generator room in winter by opening up steel trap doors in the floor, or in the summer it may be ejected outdoors through the windows in the outer wall beneath the main floor.

The rotor spider is made of cast steel and consists of three wheels, each made up of two semicircular sections bolted together at the hub and linked together to the rim by shrink keys. The rim, arms, and hub of each section are cast solid. Some manufacturers have raised objection to this type of rotor construction in large units owing to the difficulty of obtaining reliable castings. If, however, proper care is taken in annealing, testing of samples, and keeping stresses at overspeed within half the elastic limit, entirely reliable castings can be and have been made. The shaft is made of forged steel and has a solid forged flange which is bolted to the water-wheel shaft flange for coupling. The coupling bolt holes were reamed on site, thus insuring proper alignment of the two shafts.

The total weight of the complete rotor is 201 tons and the flywheel effect is 35,034,000 lb-ft.[2] In view of the enormous kinetic energy stored in the rotating parts a mechanical braking system was installed to bring the machine from normal speed quickly to rest. This braking system also helps to hold the rotor at rest against possible leakage past the water-wheel gates when the Johnson valve is not closed. The braking system is described in some detail in the original article. An interesting feature of it is that the brakes may be used when necessary as jacks to raise the rotor from the thrust bearing for inspection or repair purposes.

The generator guide bearing is of the standard babbitted type and the water-wheel guide bearing is of the water-lubricated lignum vitae type. On the machine itself is used a spring thrust bearing consisting essentially of a spring-supported stationary babbitted plate and a highly polished hard, gray-cast-iron rotating plate. The stationary plate is supported on a large number of helical springs loosely pinned to a baseplate which is doweled to the machined face of the upper bearing bracket. The flexibility of this support allows the plate to conform to the natural alignment of the shaft, thus preventing excessive local pressures in the bearing and allowing the maintenance of an oil film between the bearing surfaces.

The bearing operates in an oil bath and the heat generated is taken up by the oil as it passes by centrifugal action between the bearing surfaces. Heat is also transmitted to the oil through the metal of the bearing plates. The heat is removed from the oil by the circulating water in a stack of cooling coils immersed in the oil bath. Clean oil is pumped from a filter tank on the ground floor to an upper tank above the level of the machine. From the latter tank the oil is piped to the guide and thrust bearings, thence to a common drain which returns to the filter tank. If by any chance the oil pumps (one of which is in reserve) have to be shut down, the generator may still run if the thrust-bearing oil-supply line is shut off, as the storage tank can supply the guide bearing for several hours and the cooling coils will maintain the oil in the thrust bearing at normal temperature. (*General Electric Review*, vol. 26, no. 5, May, 1923, pp. 263–268, 7 figs., *d*)

Flow of Water Through Pipe

THE FLOW OF WATER THROUGH VITRIFIED-CLAY AND CORRUGATED-METAL CULVERT PIPE. Results of an extensive investigation conducted by the U. S. Bureau of Public Roads at the State University of Iowa Hydraulic Laboratory. Among other things capacities of the two kinds of pipe are compared and values of coefficient of roughness in the Kutter formula have been determined.

The sizes tested of each kind of pipe were 12, 18, 24, and 30 in. in diameter, and to determine the effect of the length of the culvert on its capacity the 24-in. pipe of both materials was tested in three lengths, namely, 24, 30, and 36 ft. Many different types of entrances were tried, such as various conical entrances, straight end-wall entrances, wing walls set at 45 deg. to the pipe line, and the new-type wings. The effect of varying the height of the wing wall was also tested.

The testing equipment and procedure of testing are described and the experimental results given in the form of characteristic curves for the various types of pipe and a short table.

Piezometer readings were found to be quite inconsistent and more erratic in general with the vitrified-clay pipe than with the corrugated-metal pipe. The piezometer closest to the entrance end of every pipe invariably showed a reading below the average hydraulic gradient when the velocity was high.

Perhaps the most surprising thing about these diagrams is the striking way in which they reveal the fact that for such short pipe the element of friction in the pipe itself is much dwarfed in comparison with the head consumed at entrance in getting the water into the pipe. As shown in Fig. 1, the friction head for the 12-in.

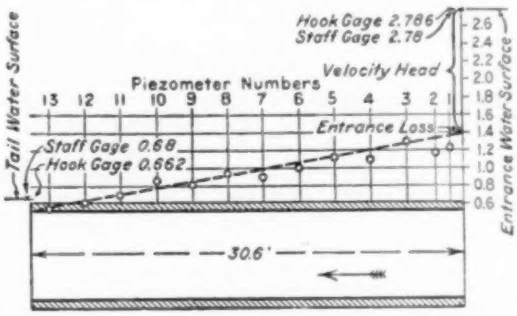

FIG. 1 12-IN. VITRIFIED-CLAY PIPE, 30 FT. LENGTH, STRAIGHT END-WALL ENTRANCE, FLAT SLOPE

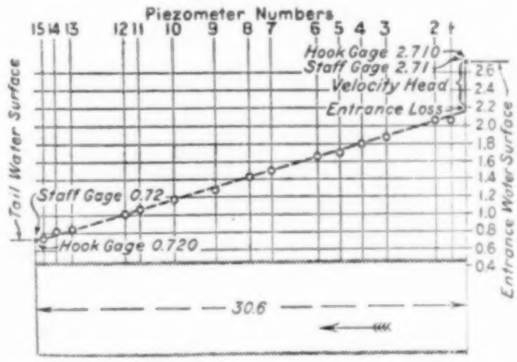

FIG. 2 12-IN. CORRUGATED-METAL PIPE, 30 FT. LENGTH, STRAIGHT END-WALL ENTRANCE

clay pipe was much less than the velocity head consumed at entrance. This relation is independent of the velocity of flow, for as the velocity increases both the friction loss and the velocity head increase in substantially the same proportion. For pipe of larger diameters the friction loss has less importance.

With corrugated-metal pipe the friction factor is much greater than with clay pipe and is therefore of greater importance. Fig. 2 shows a 12-in. corrugated metal pipe carrying nearly the same quantity of water as is carried by the 12-in. clay pipe represented in Fig. 1. Although the velocity head is about the same in the two figures, the friction head in Fig. 2 is several times as great as in Fig. 1. The friction loss in vitrified-clay pipe and corrugated-metal pipe may be compared by calculating for each the coefficient of roughness by Kutter's formula. When this was done it was found that the results varied slightly with different sizes of pipe and different velocities of flow. For clay pipe the values obtained for Kutter's exponent n varied between 0.011 and 0.014; for corrugated-metal pipe between 0.019 and 0.024. The greater resistance to flow in the metal pipe is undoubtedly caused by the corrugations. (*Good Roads*, vol. 64, no. 14, Apr. 4, 1923, pp. 131–133, 2 figs., *e*)

INTERNAL-COMBUSTION ENGINEERING (See Aeronautics; Special Machinery)

MACHINE TOOLS (See Special Machinery)

MARINE ENGINEERING

Water-Tube Boilers in Marine Service

Operation of Water-Tube Boilers in Passenger and Cargo Ships, R. Clark. A paper of largely practical character discussing the operation of three types of boilers, namely, Babcock & Wilcox, Yarrow, and Stirling, along with various automatic controls required in their operation. The author has mainly in view the Class H standard ships. These ships have a carrying capacity of 3800 to 4000 tons and are driven by triple-expansion engines.

Among other things, the author mentions that a considerable time ago, owing to certain troubles developing in cylindrical boilers, the Admiralty Boiler Committee made investigations, and it was shown that the limit to which cylindrical boilers could be worked represented a transmission of 12,000 to 14,000 B.t.u. per sq. ft. per hour; as a matter of fact the author is of the opinion that half of this rate would be a reasonable margin of safety. The inefficient circulation which sometimes results in overheating is responsible for this low transmission.

The war period has shown the mercantile service what can be done with water-tube boilers, and the author is of the opinion that the majority of new ships which will be built in the future will be fitted with water-tube boilers of some type or other because of the efficient and satisfactory performance of the same in the past, and after all it is a type of boiler which can always be depended upon to give 40 to 50 per cent of the rated capacity without injury to the tubes or the shell.

Mechanical stoking in conjunction with mechanical draft is also having serious consideration, and a large number of Babcock & Wilcox marine boilers are being fitted with several types of forced-draft stokers. However, there are certain disadvantages which must be referred to. Particularly where ships are already in service it is somewhat difficult to install the stokers, but where new ships are being built arrangements can easily be made whereby the designs can be so altered as to include the handling of the coal and ashes on an economical basis. Other disadvantages are the extra weight and complication involved, and also the difficulty of finding mechanical stokers suitable for the various classes of fuels which have to be dealt with on board ship. This difficulty, however, is gradually being overcome and the results as far as the author has been informed are very promising indeed. It is also difficult to show that mechanical stoking is an improvement over good hand firing, but the fact remains that it is difficult to find a really good fireman who will fire a boiler as efficiently and skilfully as a mechanical stoker. With a mechanical stoker one will always obtain a steady pressure. It is not necessary to clean out fires because the stokers are self-cleaning, and, taking a general view, the author is of the opinion that sooner or later a big percentage of the ships now sailing will have mechanical stokers fitted where it is absolutely necessary that vessels have to be kept to coal fuel. There can be no doubt that the water-tube boiler with its large combustion chamber can be made to suit and is far better adapted to the mechanical stokers than the cylindrical boiler, and it is on these lines that improvements are likely to materialize.

The author strongly advocates the use of oil fuel and discusses briefly the various types of oil burners. From his own tests on ships of the H-type using the forced draft he suggests that where this is done it is desirable, in order to control fully the operation of the boiler, to have the speed of the fan engines regulated by some automatic device so that when the boiler pressure rises to the working pressure the fan engine is slowed down, and when the boiler pressure falls, say, 2 or 3 lb., below the blow-off pressure the engine is speeded up again.

During the trials at which the author of this paper was present he noticed that the regulation of the fan-engine speed had to be undertaken very frequently, taking up the attention of the leading fireman when he might have been otherwise engaged. To get over a difficulty of this description an automatic fan-engine control fitted to a steam supply pipe and thence to a fan engine was designed. Fig. 3 illustrates this as working in conjunction with the Babcock & Wilcox boiler, stoker-fired.

This consists of a double-seated balanced valve, diaphragm-operated. The diaphragm chamber is connected by a copper pipe to either the boiler or the main steam pipe so that when the steam rises to blowing-off pressure the diaphragm is depressed and automatically closes the valve, shutting off steam to the engine. The reverse process takes place when the pressure is relieved due to the steam pressure falling back, say, 2 or 3 lb. This is a very useful control and has been used in a number of ships, the result being that the fireman does not require to trouble himself about regulating the speed of the fan and can devote his time to other matters.

The author further describes and advocates the use of water-level regulators such as the Babcock & Wilcox and the Crosby.

Usually when new steamers are taken over by the superintendent, and the chief engineer is installed, he is not furnished with all the records which the author considers he is entitled to.

In running trial trips it is the custom of the engineering staff responsible to the builders to take draft readings and flue temperatures at various positions in the boiler, and it is the author's contention that a set of these figures should be furnished to the chief engineer so that he can with similar instruments take records, and by these means be able to keep the water-tube boilers working in an efficient manner. The author quotes a case in point where the rate of burning per square foot of grate area was in the vicinity of 20 lb. The temperature of the escaping gases at a point in the uptake was 510 deg. fahr. The evaporation per square foot of heating surface was 4 lb. CO_2 readings ranged from 10 to 12 per cent, making an overall efficiency of 73 per cent. The engineer complained when his ship arrived back in port that he was burning too much coal, and that, therefore, the particular water-tube boiler was not efficient. It was, however, pointed out that he had never cleaned the exterior surface of the tubes and it was probable that the gases were passing into the chimney at a very high temperature. After investigation this was proved to be correct, and that particular chief engineer demanded a flue pyrometer, draft gages, and a portable CO_2 tester, and was able on his next trip to report that the escaping gases kept in the vicinity of 510 deg. fahr.; and, generally speaking, this investigation sharpened up the wits of the engineers in that particular ship and made them very keen to obtain low running costs. (Paper read Apr. 17, 1923 before the *Institute of Marine Engineers*, abstracted from advance proof, illustrated, pc)

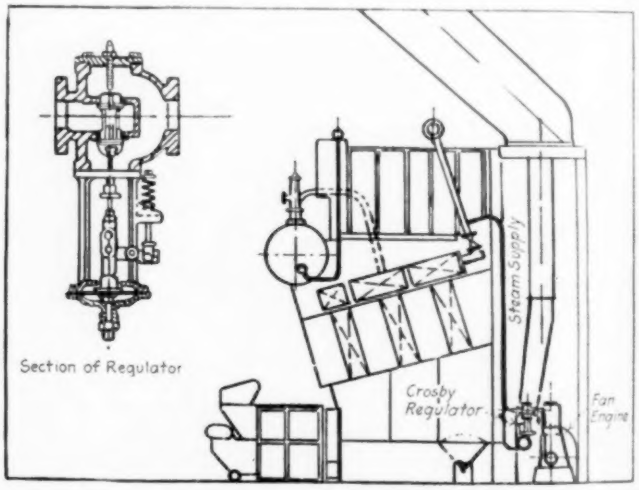

Fig. 3 Fan-Engine Control for Stoker-Fired Babcock & Wilcox Marine Water-Tube Boiler

MOTOR-CAR ENGINEERING

Andrade Differential for Motor Cars

New Differential for Motor Cars. Description of a design of differential developed by C. Andrade, Jr. It is a gearless, self-locking type and is so arranged that it delivers most, or if necessary,

all of the power transmitted to the wheel that has the most resistance on the roadbed, and therefore prevents the vehicles in which it is installed from stalling when one wheel only has traction and the other wheel is on slippery footing.

In this differential the outer or driving member is made in three parts, two of which are identical flanged hubs and the third a drum, the inner surface of which is broached to form a number of cylindrical surfaces, the axes of which lie in a cylindrical surface whose axis is the axis of rotation of the differential. The two inner driven members are splined to the axle ends and have external surfaces which are true cylinders of equal diameter. Between the driving and the driven members lie two sets of rollers, of such diameter that they clear the arcs or cylindrical surfaces of the driven member when the latter is in neutral position, as shown in Fig. 4. When the driving member starts to move ahead, the rollers all lock after they have moved about $^1/_{16}$ in. behind the center of the eccentric arcs, due to the wedging action which results.

When one of the rear wheels start to run ahead of the master gear, as the outer wheel does when the car rounds a curve, the rollers engaging that driven member roll out of locking contact and go back to the centers of the eccentric arcs. They cannot go beyond this point for the reason that the control members

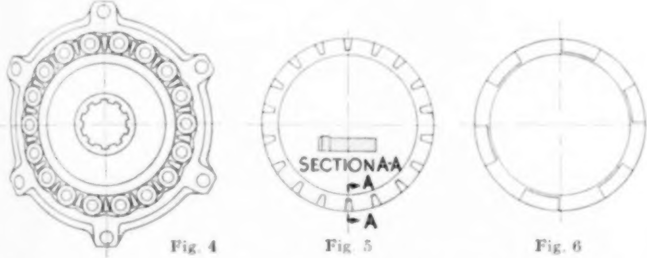

Fig. 4 Fig. 5 Fig. 6

Figs. 4, 5 and 6 Assembly and Parts for the Andrade Differential

shown in Figs. 5 and 6 prevent them from so doing. The control members are provided, on their back faces, with lugs similar to the jaws of a positive clutch, which permit them to turn only $^1/_{16}$ in. in relation to each other.

In backing the action of the differential is precisely the same as in forward motion and it also permits the normal operation of the car when the latter is going down hill and the engine is used as a brake driven from the car wheel.

Because of the large number of rollers, their considerable length, and their distance from the axle center, there is said to be only a small fraction of compressive stress on each inch of length of the rollers as there is on the gear teeth of the ordinary gear-type differential. (*Automotive Industries*, vol. 48, no. 18, May 3, 1923, pp. 979–980, 6 figs., *d*)

POWER-PLANT ENGINEERING (See Marine Engineering; Testing and Measurements)

RAILROAD ENGINEERING (See also Special Machinery)

Kunze-Knorr Air Brake. Description of a new type of air brake recently introduced on the State Railways of Sweden. It works on the principle of a single-cylinder automatic compressed-air brake.

The graduation up and down is obtained by placing a pressure transformer between the auxiliary reservoir and the valve chamber of the triple valve, by means of which the pressure in these two chambers rises and falls together in such a way that the pressure in the valve chamber of the triple valve is always higher by a certain ratio than it is in the auxiliary reservoir.

In an editorial in the same issue a careful analysis of the probable performance of the new brake is made and the conclusion to which the writer comes is that it does not appear that the new brake possesses any real advantage over the brakes that are used in the United States. (*Railway and Locomotive Engineering*, vol. 36, no. 5, May 25, 1923, pp. 143–147, illustrated, and editorial, pp. 149–150, *d*)

Newest German Type of 3-Cylinder Mikado. Description of a standard fast-freight Mikado locomotive, which is the most recent type developed in Germany. It is of the single-expansion type using superheated steam and is said to present many advantages.

It employs a crank axle, a feature which might be objected to, although with two cylinders placed outside and one inside of the frames so that the cranks form exactly or nearly an angle of 120 deg. with one another, the design of the crank axle is very simple and its manufacture is cheap compared to that of the four-cylinder locomotive which many railways were forced to abandon owing to the difficulty of manufacturing the crank axle.

The Mikado locomotive described here weighs 216,000 lb. It is intended for operation in heavy passenger as well as fast freight service and is designed for operation up to the maximum speed limit on the German railways, which is 120 km. (74.5 miles) per hour. In this locomotive the usual arrangement is found in that the main rod is connected to the second pair of driving wheels, while the return crank actuating the Walschaerts valve motion is connected to the third pair of driving wheels. This enables the use of a long eccentric rod, which serves to minimize any effect that vertical spring play of the axle in the frames may have upon the action of the valve. The piston valve controlling steam admission and exhaust from the inside cylinder is actuated by a separate valve gear connected to an eccentric crank on the left side of the locomotive. Extended piston and valve rods are used throughout.

The special equipment for this locomotive includes a pyrometer and speed indicator, also steam heat regulator. (*Railway Review*, vol. 72, no. 18, May 5, 1923, pp. 757–760, 7 figs., *d*)

SPECIAL MACHINERY

Diesel-Engine Dredge. The dredge *Elizabeth Pfeil*, the first of its type to be constructed, is equipped with Diesel-electric drive. The reason for this innovation is a practical one as the dredge is intended for service in the impure-water regions encountered in the Ohio and other rivers in the Pittsburgh district, this impure water being highly detrimental to boiler tubes.

The dredge is equipped with a 300-hp. Diesel-type, four-cylinder two-cycle, self-injection, oil-burning engine and is direct-connected to a 270-kva., 60-cycle, three-phase, 440-volt generator which drives the machinery of the entire boat.

The excavating equipment of the ladder type is made up of an endless chain of 87 manganese-steel-lipped steel buckets of 8 cu. ft. capacity weighing 1500 lb. each. This chain is mounted on a structural-steel ladder 95 ft. long, the total weight of the ladder and chain of buckets being 125 tons.

The entire operation of the dredge is controlled by one man in an elevated pilot house where there are twelve levers. From this pilot house the operator has a perfect view of the ladder and bucket line. The action of the bucket line is controlled directly by five levers connected to a 5-drum winch on the port side of the dredge forward of the tumbler center line. This winch is direct-connected by gear to a 125-hp. motor. Irrespective of the position or speed of the bucket line, complete control of the ladder and bucket line is effected at all times through brakes on the winch which hold the ladder in any position. (*Oil Engine Power*, vol. 1, no. 4, Apr., 1923, pp. 182–183, 2 figs., *d*)

Vertical Plate-Milling Machine. Description of two new tools built by Alfred Herbert, Ltd., Coventry, England, for reducing the thickness of copper plates as used in the construction of locomotive fireboxes.

Hitherto this job was done by swaging the metal down by hammering. With the new machine the preparation of the plates is reduced to a simple milling operation capable of being performed at high cutting speeds and feeds. Actual production times for this machine are not available at this moment. The machine is intended for a specific object, milling at any point on the surface of plates that may be anything up to 6 ft. sq. by $1^1/_2$ in. in thickness. It is provided with a work table of large area having longitudinal, transverse, and rotary motions and a vertical column with a long overhang to carry the spindle slide. Therefore it is possible to traverse

the plates in any direction and for the spindle to reach to the center of the maximum-size plates likely to be dealt with. The machine is not provided with low spindle speeds, but there is a range of eight of the spindle speeds varying from 100 to 350 r.p.m. which are suited for machining copper. In other respects the machine is designed and operated on the same lines as a standard vertical milling machine. The original article illustrates and describes it in considerable detail.

In conclusion it may be mentioned that the leading dimensions of the machine allow for a longitudinal feed of 78 in. and a transverse feed of 39 in. The maximum distance from the surface of the table to the end of the spindle is 13 in., while the distance from the center of the spindle to the vertical face of the column is 42 in. The working surface of the table is 78 sq. in., and the total floor space occupied by the machine is 17 ft. 6 in. sq., and its approximate net weight 40,000 lb. (*Machinery*, London, vol. 22, no. 552, Apr. 26, 1923, pp. 117–120, 4 figs., *d*)

SPECIAL PROCESSES (See Engineering Materials)

STEAM ENGINEERING (See Thermodynamics)

TESTING AND MEASUREMENTS

A Method of Determining Loss of Heat in Flue Gases Due to Incomplete Combustion, O. I. Hanson and K. E. Nielsen. An investigation conducted by the Danish Society of Fuel Economy into the composition of waste gases from steam generating plants and central heating furnaces has shown that their content of unburned gases is higher than is generally appreciated. The method of analysis by which unburned gases can be determined within a small limit of error and the calculation of heat loss from the results obtained are described in the paper. The apparatus works with a view to obtaining all the data by a single combustion analysis after the removal of carbon dioxide, and is therefore essentially different from the Orsat apparatus; it is described in detail in the original article and the errors of calculation are carefully considered. From this it would appear that the maximum percentage error of calculation of the calorific value of the fuel will only occur when either methane alone or hydrogen alone are present mixed with the carbon monoxide, and even then apparently the error will not be large enough to affect practical results. (*Fuel in Science and Practice*, vol. 2, no. 4, May, 1923, pp. 115–120, 4 figs., *d*)

THERMODYNAMICS

An Imaginary Thermodynamic Process, Jos. S. Ames. An article is not suitable for abstracting. The author assumes the existence of a being who has no knowledge of space or of space measurements but has sense organs for temperature, entropy, and force, and instruments for giving numbers to them. He makes certain other assumptions and then shows how such a being would have no trouble in comprehending the true nature of entropy. This is supposed to facilitate the understanding of entropy by ordinary students of thermodynamics. (*Journal of the Franklin Institute*, vol. 195, no. 5, May, 1923, pp. 655–663, 1 fig., *tA*)

The Supersaturation Limit—Steam at Wilson Line

The Supersaturation Limit, H. M. Martin. The author has compiled new tables of the properties of steam at the Wilson line to replace those given in his New Theory of the Steam Engine. In compiling these tables a new formula has been derived for the ratio between the actual pressure of the supersaturated steam and the pressure corresponding to the temperature. This formula is

$$\log_{10} \frac{p}{p_s} = \frac{2.96\sigma}{T}$$

where p is the actual pressure of steam when condensation commences, p_s the pressure corresponding to the absolute temperature T, and σ is the surface tension of water at that temperature. The complete derivation of this formula will be found in the original article.

The last column of Table 1 shows what the volume of the steam would have been, had it expanded in thermal equilibrium, while the column headed t_s shows the corresponding temperature. It will be seen that at the Wilson point the defect of temperature is about 28.7 deg. cent. when the condensation occurs at —10 deg. cent. The specific volume of steam at the Wilson line is very approximately 90 per cent of the specific volume at the same pressure, but at the saturation line.

The experiments of Professor Stodola confirm the view that at all temperatures the limit of supersaturation is fixed by the presence of co-aggregated molecules, the dimensions of which are independent of the temperature.

The data now most urgently required are the relationships between the pressure and volume of the steam when the expansion extends beyond the Wilson line. Mr. Wilson found in his own experiments that in this case the further condensation came down on new nuclei instead of on the droplets already formed. This shows that the temperature of the steam in this further expansion must have been that corresponding to the Wilson line and not to the saturation line. This conclusion is confirmed by the measurement of the temperature of the exhaust from steam turbines, which is commonly found to be perceptibly below the saturation temperature corresponding to the pressure. Since any thermometer placed in supersaturated steam records, not the temperature of this steam, but merely the temperature of the film of moisture which condenses on its surface, the slight defect of temperature observed is no doubt an indication of a very much larger true defect. As matters stand, however, we have no information as to the relationship between pressure and volume during most of the expansion through a low-pressure turbine, but are obliged to rely on purely empirical rules.

TABLE 1 PROPERTIES OF STEAM AT THE SUPERSATURATION LIMIT OR WILSON LINE

Temperature at Wilson point, deg. cent.	Pressure at Wilson point, lb. per sq. in.	Ratio $\frac{p}{p_s}$	Volume at Wilson point, cu. ft. per lb.	Total heat at Wilson point, lb. cent. units	Entropy at Wilson point	Equilibrium temperature, deg. cent.	Equilibrium volume, cu. ft. per lb.
t_w	p_w		V_w	H_w	ϕ_w	t_s	yV_s
—10	0.3140	7.485	896.59	589.36	2.11023	18.69	973.27
0	0.6000	6.724	486.18	594.00	1.96601	29.53	526.26
10	1.086	6.074	277.99	598.58	1.91765	40.29	300.43
20	1.875	5.517	166.37	603.07	1.87388	50.96	179.48
30	3.103	5.035	103.76	607.48	1.83419	61.56	111.78
40	4.940	4.615	67.114	611.76	1.79811	72.09	72.182
50	7.602	4.249	44.831	615.89	1.76522	82.55	48.155
60	11.34	3.926	30.496	618.06	1.73527	92.90	32.700
70	16.43	3.639	21.801	623.67	1.70789	103.17	23.364
80	23.23	3.385	15.774	627.30	1.68282	113.35	16.988
90	32.12	3.162	11.642	630.72	1.65965	123.46	12.455
100	43.46	2.959	8.775	633.97	1.63850	133.47	9.378

The determination of the true relationship between the pressure and the volume of the steam during an expansion beyond the Wilson line, should not present any insuperable difficulties. All that would seem necessary is the taking of an accurate indicator diagram by optical means under conditions in which the volume occupied by the steam was accurately known at each point of the stroke. No expensive special apparatus would seem to be necessary. The cylinder need not be more than, say, 1 in. in diameter, and its base might well form the elastic diaphragm of the indicator, while the movement of the piston might be effected by a falling weight. In order to insure a complete absence of moisture it would no doubt be advisable to work with steam which was slightly superheated at the outset. By jacketing the cylinder and piston with steam at the initial temperature no moisture would be deposited on these, while the amount of heat which could pass from these surfaces into the expanding steam during the small fraction of a second occupied by the stroke would be negligible. (*Engineering*, vol. 115, no. 2994, May 18, 1923, p. 607, *tA*)

CLASSIFICATION OF ARTICLES

Articles appearing in the Survey are classified as *c* comparative; *d* descriptive; *e* experimental; *g* general; *h* historical; *m* mathematical; *p* practical; *s* statistical; *t* theoretical. Articles of especial merit are rated *A* by the reviewer. Opinions expressed are those of the reviewer, not of the Society.

ENGINEERING RESEARCH

A Department Conducted by the Research Committee of the A.S.M.E.

Résumé of the Month

A—Research Results

The purpose of this section of Engineering Research is to give the origin of research information which has been completed, to give a résumé of research results with formulas or curves where such may be readily given, and to report results of non-extensive researches which in the opinion of the investigators do not warrant a paper.

Framed Structures A2-23. Compression Tests of Structural Steel Angles. This article, known as Technologic Paper No. 218, presents the results of compression tests of 170 structural angles, made at the Pittsburgh branch, Bureau of Standards, by A. H. Stand and L. R. Strickenberg. The object of the tests was to determine the ultimate compressive strength of angles fastened at the ends in such ways as would closely correspond to their connections in the construction of transmission towers. There was also tested a series of angles with square ends. An end fixation factor was found to represent satisfactorily the effect of different types of end connections. Using this fixation factor, the average values for large slenderness ratios were well represented by Euler's formula. The results obtained from shorter columns agreed with the experimental and theoretical results of Karman. The effect of eccentric loading was most marked at the slenderness ratios indicated by Karman's theory. Price per copy, 10 cents. Address Superintendent of Documents, Government Printing Office, Washington, D. C.

Properties of Engineering Materials A2-23. Some Tests of Steel-Wire Rope on Sheaves. This Technologic Paper No. 229 has been just published by the Bureau of Standards. It was prepared by Edward Skillman from data obtained as a result of tests made at the request of the erection department of the American Bridge Company.

Tests of wire rope $^5/_8$, $^3/_4$, $^7/_8$, 1, and $1^1/_4$ in. in diameter were made on sheaves of 10, 14, and 18 in. diameter to determine their strength under static load. The ropes were all of 6-strand, 19-wire construction made from "plow" steel. It was found that the strength on sheaves was less than that of the straight ropes, the ratio of the strengths being 0.87 for $^5/_8$-in. rope on 10-in. sheaves and 0.95 on 18-in. sheaves; for $1^1/_4$-in. rope the corresponding values were 0.76 and 0.85.

The tensile strength of individual wires was about 230,000 lb. per sq. in., elongation in 8 in. about 2 per cent, and reduction of area about 46 per cent. These were practically the same for all sizes of wire. The strength of the straight ropes followed closely the equation $S = 83{,}000\ d^2$, in which S is the strength in pounds and d the diameter of the rope in inches. One worn rope which was tested showed a surprisingly high strength when its condition is considered.

A point of inflection in the load diagrams was found at from 56 to 65 per cent of the ultimate load, above which the elongation increased rapidly. The elongation of straight rope over a gage length of about 40 in. was about 2.5 per cent and the reduction of diameter about 4 per cent. The modulus of elasticity of a new rope was about 8,500,000 lb. per sq. in. and of worn rope about 13,500,000 lb. per sq. in.

Price per copy, 10 cents. Address the Superintendent of Documents, Government Printing Office, Washington, D. C.

Iron and Steel A5-23. Some Tests of Steel-Wire Rope on Sheaves. See *Properties of Engineering Materials A2-23.*

Properties of Engineering Materials A3-23. Investigation of the Fatigue of Metals Results of 1922. In the February, 1922, issue of Mechanical Engineering the first report of this investigation (Bulletin No. 124) was listed under "Mechanics A1-22." This second printed report was prepared by Messrs. H. F. Moore and T. M. Jasper and is known as Bulletin No. 136 of University of Illinois Engineering Experiment Station.

The tests recorded in this bulletin have all been made on specimens of wrought ferrous metal, free from flaws and large inclusions, as shown by micrographs, and tested under continuous series of cycles of stress. All specimens were turned with the longitudinal axis in the direction of rolling of the steel. The information gained from these specimens may not be true for steel with serious flaws or large inclusions, nor should such conclusions be extended to cast steel, cast iron, or non-ferrous metals. Subject to the above limitations, the conclusions drawn from the tests herein recorded may be summarized as follows:

1 A study of the test data obtained as well as of those secured from other laboratories tends to confirm the existence of an endurance limit for wrought ferrous metals, the endurance limit being defined as the unit stress below which a metal is capable of withstanding an indefinitely large number of reversals of stress.

2 The test results obtained and those from other laboratories confirm the conclusion drawn in Bulletin No. 124 that the endurance limit of a wrought ferrous metal may be determined with a fair degree of accuracy by a short-time test in which the rise of temperature under reversed stress is measured.

3 The tests recorded in this bulletin confirm the conclusion drawn in Bulletin No. 124 that for wrought ferrous metals the endurance limit seems to be correlated with the ultimate tensile strength, with the Brinell hardness number, and in a much smaller degree with the yield point and the proportional elastic limit. No correlation was found between the endurance limit and the ductility, the results of Charpy impact tests of notched bars, or repeated-impact tests.

4 The effect of speed of reversal of stress on the determination of the endurance limit seems to be slightly below a speed of 5000 r.p.m. for tests made on a Farmer rotating-beam testing machine. A slight increase of endurance limit was noted for increased speed of reversal of stress.

5 The results of the tests of specimens with various temperatures of "draw" after oil quenching indicate that for the carbon-steel specimens tested neither the ultimate tensile strength, the endurance limit for flexure, nor the ductility was appreciably affected by draws at a temperature lower than 600 deg. fahr. For the nickel-steel specimens for draws up to 400 deg. fahr. the ultimate tensile strength and the endurance limit for flexure diminished slightly while the ductility increased a little. For draws at higher temperatures the changes in values of strength and ductility were more marked, the ultimate tensile strength and endurance limit decreasing, and the ductility increasing. Whatever advantages may be gained by draws below about 600 deg. fahr. such as relief from internal stress and increased machinability, may be attained with but little, if any, sacrifice of tensile strength or of endurance strength under flexure.

6 The results of tests of the specimens subjected to severe tensile overstress before being tested in reversed bending indicate that a few applications of stress, well above the proportional elastic limit of the metal, lowered the endurance limit under subsequent reversed stress, the endurance being diminished by 22.9 per cent of its original value for one set of specimens. The effect of polishing the specimens after overstressing has not yet been investigated. Placing the specimens in boiling water did not seem to have any appreciable beneficial effect on the endurance limit.

7 From the test data recorded in this bulletin the following tentative formula is given for wrought ferrous metals as expressing with a fair degree of accuracy the relation between the endurance limit for cycles of completely reversed stress and the endurance limit for cycles of stress not involving complete reversal:

$$S_r = S_{-1}\left(\frac{r+3}{2}\right)$$

in which r is the algebraic ratio of minimum stress to maximum stress during a cycle of stress (for completely reversed stress, $r = -1.0$), S_r is the endurance limit for ratio r, and S_{-1} the endurance limit for completely reversed stress.

8 If a specimen or machine part is subjected to cycles of repeated-bending stress higher than the proportional elastic limit of the metal, the tests indicate that there may result a failure by excessive distortion of the specimen or the machine part. The endurance limit under repeated-bending stress should, then, never be considered as higher than the proportional elastic limit of the metal.

Iron and Steel A6-23. Investigation of the Fatigue of Metals Results of 1922. See *Properties of Engineering Materials A3-23.*

Mechanics A1-23. Investigation of the Fatigue of Metals Results of 1922. See *Properties of Engineering Materials A3-23.*

Fuel Utilization A5-23. Preparation, Transportation, and Combustion of Powdered Coal. This pamphlet, known as Bureau of Mines Bulletin 217, by John Blizard, sets forth the many methods, advantages and disadvantages of preparing and burning powdered coal, and states that manufacturers and operators of coal-fired furnaces cannot afford to disregard the advantages of pulverizing their coal before burning it.

The chapter headings, which are as follows, give a good idea of the scope of this publication: I, Powdered Coal, Definitions and General Discussion; II, Preparation of Powdered Coal; III, Distribution of the Powdered Coal; IV, Feeders, Mixers, and Burners—Bin-at-Furnace System; V, Uses of Powdered Coal; VI, Powdered Coal for Steam Raising; VII, Costs of Preparing and Delivering Powdered Coal to the Furnace; VIII, Danger from Use of Powdered Coal; and IX, Conclusions. Price per copy, 50 cents. Address the Superintendent of Documents, Government Printing Office, Washington, D. C.

Refrigeration A2-23. Tables of Thermodynamic Properties of Ammonia. These tables are the result of measurements made by the Bureau of Standards to determine fundamental physical data of refrigerating engineering. The Bureau's researches in this field were undertaken in response to the wishes of the refrigerating industry as expressed through its national associations and were specifically authorized by act of Congress. In carrying out the experimental program the bureau has had the benefit of the advice of The American Society

of Refrigerating Engineers, one of the organizations which originally requested that the work be done.

The tables, which are published in foot-pound-fahrenheit units only, embody the results of an elaborate series of measurements of the thermodynamic properties of ammonia. The fundamental units and constants used in the tables are defined. The empirical equations used in computing the tables, and also the references to the publications dealing with the experimental data, are given The tables have been prepared in the forms convenient for use in refrigerating engineering. The same data are also presented graphically in the form of a Mollier chart.

Price per copy, 15 cents. Address Superintendent of Documents, Government Printing Office, Washington, D. C., asking for Bureau of Standards Circular No. 142.

F—Bibliographies

The purpose of this section of Engineering Research is to inform the profession of bibliographies which have been prepared. In general this work is done at the expense of the Society. Extensive bibliographies require the approval of the Research Committee. All bibliographies are loaned for a period of one month only. Additional copies are available, however, for periods of two weeks to members of the A.S.M.E. These bibliographies are on file at the headquarters of the Society.

Petroleum and Allied Substances F2-23. This Bulletin No. 216, covering the years 1919 and 1920, is the fifth in the series of petroleum bibliographies published by the Bureau of Mines, Bulletins 149, 165, 180, and 189 being compilations for the years 1915, 1916, 1917, and 1918, respectively. The publications examined number 169 and include both domestic and foreign. The references are arranged under the following headings: (000) General treatises; (100) Countries and regions; (200) Geology and origin; (300) Development and production; (400) Transportation, storage, and distribution; (500) Properties and their determination; (600) Refining and refineries; (700) Utilization; (800) Legislation and legal regulations; and (900) Miscellaneous.

Price per copy, 40 cents. Address the Superintendent of Documents, Government Printing Office, Washington, D. C.

CORRESPONDENCE

Contributions to the Correspondence Department of Mechanical Engineering are solicited. Contributions particularly welcomed are discussions of papers published in this journal, brief articles of current interest to mechanical engineers, or comments from members of The American Society of Mechanical Engineers on activities and policies of the Society in Research and Standardization.

The Efficiency of the Scotch Marine Boiler

To the Editor:

Mr. C. J. Jefferson's article in the April Mechanical Engineering on the Efficiency of the Scotch Marine Boiler shows very good results for the recent tests on two Scotch marine boilers by the U. S. Shipping Board and the Bureau of Mines, but there are several points regarding the tests which differ from marine practice and which should be added to his article.

One of the most noticeable things in the test is the variation in the average feedwater temperatures, which ranged from 288 to 212 deg. fahr., with one temperature of 232 deg. It is interesting to note that the highest boiler efficiency was obtained with the lowest average feedwater temperature used in any of the runs. Had a higher feedwater temperature been used in this run the boiler efficiency would have undoubtedly been higher, as by a rule of thumb a saving of one per cent in fuel is obtained for each increase of 10 deg. fahr. in the temperature of the feedwater. This is one of the things about which marine engineers are particularly careful, and temperatures of from 220 to 230 deg. fahr. are the usual practice, and are obtained by having a back pressure of between 2 to 6 lb. gage on the auxiliary exhaust which is used to heat up the feedwater. Higher temperatures up to 240 deg. are sometimes used, but any temperature requiring an auxiliary exhaust pressure more than 10 lb. gage is not good practice. By carrying a high feedwater temperature there is a saving in fuel, and this temperature is easily read with a thermometer. The adjustment of the valves to carry the proper auxiliary feed pressure for the desired feedwater temperature is readily made and need not be changed ordinarily under constant working conditions.

The introduction of flue-gas analysis has been slow in marine work, probably due to the idea that it is a complicated process. It also requires chemicals of known strength, which are not readily obtainable everywhere, and some of them are liable to deteriorate if not kept properly. It is true that flue-gas analysis requires a certain knack to obtain proper results, but given a few simple instructions, it would seem that marine engineers would quickly learn to make accurate readings. After using this method to learn what is going on in the furnace, and making the required changes in the operation of the boilers to suit such an analysis, a very real saving in fuel would result in a large number of cases. The use of automatic CO_2 and CO recording instruments has not been possible, due probably to the delicacy of the instruments, which are so devised that they can only be used for stationary work.

Pyrometers are used in navy work to indicate the temperature of the gases as they leave the boiler. It seems that they would be equally valuable in merchant-marine work, and would afford the engineer some indication of how much heat is going up the stack and being wasted.

The marine engineer is also handicapped by not having a definite means provided for measuring the amount of water fed to the boiler, and when using coal for measuring the exact amount fired. Approximations may be used in both cases—for example, so many pounds of coal in a wheelbarrow—and with a well-made-up system of piping and no free escapes of steam the amount of make-up feed used is a fairly definite proportion of the water fed to the boilers. Also for a complete analysis of boiler conditions an instrument for determining the quality of the steam—if not superheated—would be required.

A further important thing in marine work is the use of a calorimeter for determining the fuel value of the coal or oil used. This would give the engineer an idea of the quality of the fuel he was using, and would also be of great value in its purchase. The recent high price of coal and its poor quality will undoubtedly hasten the use of a calorimeter for this work.

Such items as keeping the boiler clean by opening at the proper intervals, blowing the tubes regularly, keeping the boiler water slightly alkaline and not too salty, and all apparatus in good working condition, are too well known to need any discussion.

These, then, are the principal items in which it seems to the writer that this test differs from ordinary present merchant-marine practice. In addition he does not himself know of any case in marine work where the gases leaving the furnace are used to heat up the air fed to the boiler, but of course this system is valuable as far as the boiler efficiency is concerned.

Washington, D. C. Charles D. Shepard.

[Mr. Shepard's communication was placed before Mr. Jefferson, the author of the paper, from whom the following letter has been received.—Editor.]

To the Editor:

In regard to Mr. Shepard's letter commenting on the article on Scotch marine boilers, the writer would like to submit the following remarks:

1 *Feedwater Temperature.* All the efficiencies as listed in the heat balance of this test were determined from the equivalent of the evaporation figures which automatically take care of the feedwater temperature.

The writer has found it common practice in marine service to operate with 15 lb. back pressure, and on several of our best performers we have gone still further and installed a second feed heater which utilizes the auxiliary exhaust from such auxiliaries as are run on full boiler pressure, these auxiliaries being run at 35 lb. back pressure. The purpose of the second feed heater using the higher

back pressure is to boost up the feed temperature to about 270 deg. This has resulted in increased economies as high as 7 per cent of steam for our turbine-driven ships where the auxiliary steam being taken away from the main condenser permitted higher vacuums to be obtained on the main unit and the increased boiler-feed temperature resulted in reduced maintenance charges.

2 *Flue-Gas Analysis.* Mr. Shepard comments regarding the fact that the adoption of flue-gas analysis for the use of determining boiler efficiencies in marine practice has been somewhat slow. You are advised that we have found this only too true, and it is to overcome such conditions as this that the Fuel Oil School has been started at the Philadelphia Navy Yard. It is proper to say, however, that while there were practically no Orsats in use in our fleet a year ago, now practically 50 per cent of the vessels are equipped with this instrument and the *engineers are using them.*

3 *Use of Pyrometers.* The pyrometer has been installed for some time in merchant vessels, but in common with a great many other similar power-plant installations, proper regard has not been given to its location. In order to get really worth-while data for operating purposes, it is necessary that the pyrometer be installed as close as possible to the point where the gases leave the boiler. This in the Scotch boiler really means, on a three-furnace job, three pyrometers. When the pyrometer is installed in the stack halfway up the fiddley, the temperatures observed are not trustworthy for determining efficiency of operation as this temperature is generally affected considerably by minor leakage through breechings and uptakes.

4 *Use of the Fuel Calorimeter.* The writer's personal experience with the fuel calorimeter forces him to the conclusion that this is a laboratory instrument, and if used by inexperienced persons would lead to very erroneous conclusions.

5 *Use of Air Heaters.* Mr. Shepard states that he knows of no case where the gases leaving the furnaces are used to heat up the air fed to the boiler. This system of air heater was developed by James Howden a number of years ago and is in use on practically all Scotch boiler installations, as well as the majority of the large passenger vessels such as the *Leviathan*, etc.

New York, N. Y. C. J. Jefferson.

Locating Leaks in Underground Pipe Lines

To the Editor:

Locating leaks in underground steam and water lines is usually expensive. In the case of steam and return lines the first evidence appears as steam from the manholes or water or steam from the outlets of the underdrains. The exact location of the leak is determined by putting down one or more test excavations along the line until the leak is found.

The geophone, an instrument developed during the war for detecting vibrations of the earth due to tunneling, etc., was recently tried for locating leaks in underground piping systems of an eastern university with the following results:

The first leak was in the return of the heating system and was located accurately under 4 ft. of cover.

The second leak was in a domestic hot-water pipe encased in a concrete duct packed with mineral wool and under 4 ft. of cover. The line extended from a tunnel to a building 250 ft. away. The evidence of the leak appeared as warm water from the underdrain into the tunnel. The leak was located 200 ft. from the tunnel and proved to be a pit hole in the pipe about $^3/_{16}$ in. in diameter.

The third case was in a 5-in. steam line carrying 10 lb. steam pressure. The line is encased in a concrete duct. The leak was located at a point which proved to be $9^1/_2$ ft. underground.

In all these cases the leaks were plainly audible for ten or more feet each side of the point at which it was finally decided that the disturbance was loudest. In each case the first excavation put down centered on the leak.

The above trials indicate that the geophone can be very profitably used for locating leaks in like underground lines. [Its use in locating leaks in compressed-air lines was described in Mechanical Engineering, November, 1922, p. 741.—Editor.] The instrument and some of its applications are described in Technical Paper 277, Department of the Interior, Bureau of Mines.

Ithaca, N. Y. H. A. Ward.

A.S.M.E. Boiler Code Committee Work

The Boiler Code Committee meets monthly for the purpose of considering communications relative to the Boiler Code. Any one desiring information as to the application of the Code is requested to communicate with the Secretary of the Committee, Mr. C. W. Obert, 29 West 39th St., New York, N. Y.

The procedure of the Committee in handling the cases is as follows: All inquiries must be in written form before they are accepted for consideration. Copies are sent by the Secretary of the Committee to all of the members of the Committee. The interpretation, in the form of a reply is then prepared by the Committee and passed upon at a regular meeting of the Committee. This interpretation is later submitted to the Council of the Society, for approval, after which it is issued to the inquirer and simultaneously published in Mechanical Engineering.

Below are given the interpretations of the Committee in Cases No. 412–417, inclusive, as formulated at the meeting of March 22, 1923, and approved by the Council. In accordance with the Committee's practice, the names of inquirers have been omitted.

Case No. 412

Inquiry: Is it permissible, under the Code, to use on boilers, pressed-steel nozzles having the upper or bolting flange of the Vanstone joint construction, with the bolt-flange made of steel?

Reply: While the form of construction proposed for a boiler nozzle embodying the use of the Vanstone joint, as outlined, does not conflict with the requirements of the Code, provided the flange, dimensions, etc., meet the requirements of the Code for pipe flanges, it is the opinion of the Boiler Code Committee that a rigidly attached form of nozzle flange is preferable.

Case No. 413

Inquiry: What is the permissible stress for screwed stays with ends riveted over less than 20 diameters in length, when such screwed stays are inserted in the sheets at an angle that is not truly radial in the case of curved plates, or in the case of flat plates is not normal to the plane of the plate?

Reply: It is impossible to formulate any logical requirement for a condition of that sort and it must be a matter of judgment. A revision of the Code has been proposed which reads as follows:

"All staybolts not normal to the stayed surface shall have not less than three engaging threads, of which at least one shall be a full thread."

The angularity in such case should not exceed 15 deg. to the stayed sheet. If the angularity is greater than 15 deg. it must be taken into account in calculating the permissible stress in the staybolt.

Case No. 414—(In the hands of the Committee)

Case No. 415

Inquiry: Where a boiler of the locomotive type is fitted with a form of removable drum, attached by bolted connection to the outlet nozzle, as is customary practice in the California oil fields, is it the intent of the Code that the requirements of Par. 194 shall apply to the construction of the drum, or can this construction be considered as a steam drum subject to the requirements of Par. 187?

Reply: It is the opinion of the Boiler Code Committee that the form of construction shown is not a boiler dome and therefore does not come under the requirements of Par. 194 of the Code, but must be considered as a steam boiler drum coming under the provisions of Pars. 187 and 188.

Case No. 416—(In the hands of the Committee)

Case No. 417

Inquiry: Is it the intent of the Code to require any particular design for suspension lugs to support horizontal-return-tubular boilers 78 in. or less in diameter?

Reply: It is the opinion of the Committee that it was not the intent of the Code to require any particular design for suspension lugs to support horizontal return-tubular boilers 78 in. or less in diameter, but that any such lugs should conform to the requirements of Pars. 324 and 325 of the Code.

MECHANICAL ENGINEERING

A Monthly Journal Containing a Review of Progress and attainments in Mechanical Engineering and Related Fields, The Engineering Index (of current engineering literature), together with a Summary of the Activities, Papers and Proceedings of

The American Society of Mechanical Engineers

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Uniform Safety Legislation

Harris and Ewing

M. G. Lloyd

THE administration of industrial accident prevention in this country differs widely from state to state. Legislation is now in force in different states providing either: (1) a commissioner of labor statistics whose duty is to collect and report information; (2) statutory requirements for accident prevention; (3) statutory requirements for accident prevention supplemented by a staff of factory inspectors to enforce these requirements; (4) a board or commission having power to make detailed regulations—usually with reference to only one subject or industry; (5) officials or commissions with power to make detailed regulations for industries in general, with a staff of inspectors to enforce both statutory requirements and commission orders.

The experience which has now been obtained is sufficient to enable us to form a definite idea as to the type of legislation which will secure the best results, although this idea may have to be modified to some extent by local differences in political or industrial conditions. It should be noted that most of the prominent industrial states have adopted the method of delegating the legislative authority for enacting regulations to the administrative officials who are concerned with the enforcement of the regulations, and whose regular duties bring them into contact with working conditions as they are met in industry. There are now 17 states where such powers for industries in general have been given to an industrial commission or similar officials, and there are others where similar powers with respect to mining or public utilities reside in a separate commission. This may be regarded as the complete development of the system of protection for the worker against industrial accidents. This system has the advantage over statutory requirements that the regulations may be changed with comparative ease when experience, advancement in the arts, or wider knowledge of industries and processes shows such amendment to be desirable. It is then unnecessary to wait for a legislative session or to convince legislators, who are unfamiliar with the details of the matter and who are largely occupied with matters of a political nature, of the desirability of the change. It is also possible to cover additional industries or new conditions in old industries as soon as the subject may demand attention. It is also possible to give the detailed requirements much more extensive and more technical study than it is possible for legislators to give. The regulations are consequently likely not only to be more complete and more adaptable to conditions, but also more satisfactory both to the inspector and to those who must comply with them.

It would consequently seem desirable in future legislation on this subject that those who are attempting to improve present conditions should work toward the establishment of administrative authorities with full powers to make the detailed regulations which are to be enforced, and to combine with this the authority to amend regulations which have already been placed upon the statute books. In many cases such regulations have become obsolete before they have been repealed or amended by later statutes. This is one of the most objectionable features of detailed statutory requirements, which usually do not permit exercise of any discretion upon the part of the inspector or administrator.

M. G. Lloyd.[1]

The Pittsburgh Power Survey

TWO YEARS AGO public attention was attracted and the popular imagination fired by an announcement by the United States Geological Survey that a superpower system was being planned for the region between Boston and Washington. In its report on the subject the Geological Survey pointed out the possibilities of great economies in power production by interconnection and combination of power-producing facilities. The investigation on which the report was based was prompted by a far-seeing idea that economical power production must be the basis for future industrial expansion, and a requisite for the advance of our civilization.

In the discussion of papers on hydroelectric development at the Spring Meeting of the Society, William M. White called attention to the facts that the productivity of the workers of each country and the rates of wages paid to each worker bear a definite relation to the amount of mechanical power per worker. He also emphatically stated that the public must look to the engineer to point the way in developing nature's resources to minimize human toil. The utilization of power to meet the needs of our industries and to provide the many varied articles that make modern life possible is therefore a grave responsibility of the present generation of engineers. To bear this responsibility properly, however, the engineering profession must have facts, and many careful studies, such as those relating to the superpower system, must be carried on.

The investigation recently conducted in the steel industries in the Pittsburgh district, as reported in the leading article by Professors Ely and Rittman in this issue of Mechanical Engineering, furnishes important facts upon which principles for the more economical use of power and fuel may be based. An interpretation of the facts and trends of this paper lead to a much more thorough appreciation of the importance of power in all the American industries.

The effect of this survey in the Pittsburgh district itself must have been very helpful. It emphasized as the authors point out, the need for greater completeness and uniformity of power and fuel records in the steel industry. It has brought out coöperation between the various components of the steel industry and the producers of electrical energy in the district.

The results of the study bear witness to the confidence the industries of Pittsburgh place in the Carnegie Institute of Technology and in the authors. Such confidence must be the basis on which accurate statistics of this kind are developed.

The Engineer's Job

THE quotation on the cover of this issue of Mechanical Engineering is from an address delivered before the Engineers' Club of Philadelphia as reported in the January issue of *Engineers and Engineering*. Dr. Frank Aydelotte, the author of the quotation, in addition to being President of Swarthmore College, is American Secretary of the Rhodes Trustees, a trustee of the Carnegie Foundation for the Advancement of Teaching and a member of a number of educational and scientific bodies.

[1] Chief of Safety Section, Bureau of Standards, Washington, D. C.

World Power Conference

A WORLD Power Conference will be held in London next year to determine how the industrial and scientific sources of power may be adjusted nationally and internationally. This conference is to be held at the time of the British Empire Exhibition, but is an independent undertaking under the auspices of the British Electrical and Manufacturers' Association. General committees are being formed in Great Britain, France, Italy, Norway, Sweden, Czechoslovakia, Canada, and other countries, to arrange for participation in the conference. Members of engineering organizations in the respective countries are serving on these committees.

In the United States, a preliminary meeting was held on February 8 to consider participation by this country. A special committee, consisting of J. W. Lieb, Chairman, H. J. Pierce, Calvert Townley, W. H. Onken, Jr., F. R. Low, and O. C. Merrill, was appointed to draw up a plan of organization. Its report was submitted and approved at a second meeting on May 4. A final organization meeting was held in New York on June 20, at which engineering and technical societies, business associations interested in power, and government agencies were represented, making up the general committee. The organization for this country's participation was effected and an executive committee chosen to work out the details. Members of the national societies who are serving on the general committee are Peter Junkersfeld and George C. Orrok, A.S.C.E.; D. B. Rushmore, A.I.M.E.; and F. R. Low, D. B. Rushmore, and F. D. Herbert, A.S.M.E.

This important conference is one of a series of international events in which the American engineers are participating, all tending to strengthen the international bonds between engineers.

French Engineering Society Celebrates Seventy-Fifth Anniversary

IMPRESSIVE excerises marked the three-day celebration in Paris, May 4, 5, and 6, of the seventy-fifth anniversary of the founding of the Société des Ingénieurs Civils de France. The American Society of Mechanical Engineers was represented at the celebration by Past-President Jesse M. Smith and Laurence V. Benet, Honorary Vice-Presidents for the occasion by Council appointment.

Mr. Smith was selected by the Société to be spokesman for all the American societies represented at the opening reception and he delivered an appropriate and eloquent address.

The principal session on May 4 was presided over by M. Millerand, President of the French Republic. Two technical papers were presented: The Metallurgical Industry, by M. R. Jordan, and Large Electric Transmission Systems, by MM. Janet and Bizet.

The feature addresses, however, were delivered the following morning, when General Ferrie spoke on Hertzian Waves and Their Application, M. Soreau on Aeronautics, and M. Percheron on the Guidance of Airplanes by Radiotelegraphy. This session was followed by an excursion to Bourget, where the installation and organization of the greatest airport in the world were examined in detail. The regularity of the arrival and departure of mail- and passenger-carrying planes was most impressive, and the statistics given of the amount of mail and freight and the number of passengers carried during the past year without accident demonstrated that the air service has become an essential part of the transportation system of France.

Sunday morning, May 6, was marked by a reception to M. Eiffel given on the second platform of the Eiffel Tower. In spite of his 91 years, M. Eiffel delivered an address of welcome which was greatly appreciated by a large audience.

Several brilliant social affairs were held, the last of which was a banquet of about 400 covers addressed by delegates from all the foreign countries and by M. Le Troquer, a member of the French Cabinet. Here again Mr. Smith represented the United States of America, and his speech was warmly applauded. Sir Archibald Denny was Great Britain's representative.

Laurence V. Benet, one of the Society's representatives at the celebration, represented it twenty-five years ago at the fiftieth anniversary exercises of the French Société, and spoke then on behalf of American engineers.

Dr. de Margerie Honored by U. S. Engineers

A RECEPTION and luncheon in honor of Dr. Emmanuel de Margerie, second exchange professor from France to this country, was held at the Harvard Club, New York City, May 18, 1923: Arrangements were made by a committee of the A.S.C.E., A.I.M.E., A.S.M.E., and A.I.E.E., and the guests included present and past officers of those societies and their joint organizations; representatives of the seven universities on the exchange list; Dr. A. E. Kennelly, last year's exchange professor to France; Dr. Charles F. Scott, president of the Society for the Promotion of Engineering Education; Dr. Stephen Duggan, director of the Institute of International Education; M. Gaston Liebert, former consul-general in New York, now director of the French Bureau of Information in New York City; and M. Charles Baret, successor of M. Liebert as consul-general in New York, representating Ambassador Jusserand. Dr. A. R. Ledoux, chairman of the committee on arrangements, acted as toastmaster.

Dr. de Margerie, who during the past year has lectured at Columbia, Cornell, Harvard, Johns Hopkins, Massachusetts Institute of Technology, University of Pennsylvania, and Yale, is director of the Geological Survey of Alsace-Lorraine, and chief geologist of the Geological Survey of France. He is a member of and holds medals from leading American and French geological societies, the latest honor conferred upon him being the Mary Clark Thompson gold medal of the National Academy of Science of the United States.

Dr. Kennelly, who is now professor of electrical engineering at Harvard and M.I.T., introduced Dr. de Margerie, referring to his work, which carries him over the political boarders of France into other countries, as another illustration of what modern science is doing for us in linking us all together.

"Unity of thought" between the scientist and the engineer, the influence of the engineer in the development of the community, and the large number of educational institutions, are among Dr. de Margerie's impressions of America, as stated by him in a brief address at the luncheon. Both M. Baret and M. Liebert also spoke.

This occasion marked the close of the second year of exchange professorships in engineering and science between the United States and France. The plan, which was inaugurated by the late Dr. Maclaurin of M.I.T., purposes to bring about a closer relation of science and engineering between the two countries, through the influence of personalities as well as the exchange of ideas.

Rudolph Hering, Dean of Sanitary Engineers, Dies

RUDOLPH HERING, consulting hydraulic and sanitary engineer of New York City and an authority on municipal water supply, sewage, and garbage disposal, died on May 30, 1923. Mr. Hering was born in Philadelphia, Feb. 26, 1847. He was educated in Dresden, Germany, and was graduated from the Royal Polytechnic College of Dresden as a civil engineer in 1867. He returned to this country shortly afterward and became assistant engineer to the Board of Public Works of Philadelphia. In 1881 he visited Europe again to study sewage-disposal methods for the National Board of Health.

From 1883 to 1885 he was engineer in charge of the new water supply of Philadelphia, and during the next two years was chief engineer of the Chicago Drainage and Water Supply Commission. From 1888 until 1920, when he retired from active practice, Dr. Hering was engaged in consulting work for water supply and sewage works for practically all of the larger cities in the United States and Canada. As a member of a New York firm of consulting hydraulic and sanitary engineers for many years he served the Department of Water Supply, Gas and Electricity of that city.

Dr. Hering was the author of several technical books, and the recipient of the honorary degree of Doctor of Science from the University of Pennsylvania. He belonged to the American Society of Civil Engineers, the Canadian Society of Civil Engineers, the Institution of Civil Engineers, The Franklin Institute, the American Water Works Association, the New England Water Works Association and the American Public Health Association, and was a Fellow of the American Academy of Science. He became a member of The American Society of Mechanical Engineers in 1906.

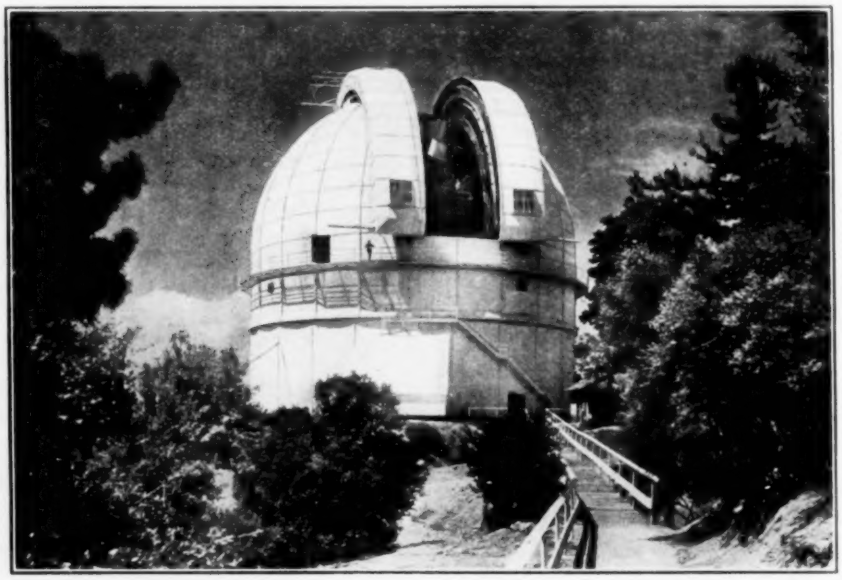
Engineering Achievements of Pacific Coast Shape Program for Regional Meeting

Los Angeles Headquarters for Second A.S.M.E. Regional Gathering—California's Remarkable Progress in Engineering Described in Addresses and Viewed on Excursions

THE SECOND A.S.M.E. regional meeting, held in Southern California April 16–18, 1923, under the auspices of the Los Angeles Local Section, matched its predecessor, at Springfield, in success. The Hotel Alexandria, Los Angeles, was headquarters for the meeting and there, on the opening day, the first and only session designated as technical was held. After that the program demonstrated once again the fundamentally technical character of excursions which are opportunities for gathering scientific information rather than mere sightseeing expeditions.

An account of the technical session is given in succeeding columns. On the afternoon of April 16 an opportunity to study engineering work in the motion-picture industry was given in an address by Mr. Langey of the Pickford-Fairbanks studio, followed by an inspection of the studio in Hollywood.

On April 17 the meeting moved on to Pasadena where the morning was spent at the Norman Bridge Laboratory of Physics at the California Institute of Technology. Prof. E. C. Watson, who conducted the party about the laboratory, explained a number of interesting things, including the use of the special screen for vertical projection by showing the principles of wave motion as illustrated in a ripple tank; some slides of actual photographs of sound waves; the power of the circuits to the lecture room by means of an experiment on electromagnetic repulsion in which an aluminum ring was thrown to the ceiling; acoustics of the room as illustrated by sounds produced in large pipes by heat vibrations; some experiments with ultra-violet light, showing the peculiar fluorescence produced in many substances, etc.



Dome of 100-in. Hooker Reflecting Telescope, Mt. Wilson Observatory

The afternoon was spent at the laboratory and shops of the Mt. Wilson Observatory. One of the most interesting machines which the members were allowed to inspect was a ruling engine, perfected by one of the members of the staff, and representing many years of study. With this engine it is hoped that 100,000 lines to the lineal inch can be ruled. A sample of the work of the machine, carrying 15,000 lines ruled to the lineal inch, was an object of great interest.

Late in the afternoon the party motored to the top of Mt. Wilson, where the night was spent. In the evening Prof. Francis G. Pease, astronomer in charge of design at the observatory, gave details regarding the 100-in. Hooker reflecting telescope there installed, the most powerful instrument of its kind yet constructed. Extracts from his description are given later in this account. A heavy fog made impossible the demonstration of this and other instruments that evening, but early the next morning many of the party inspected the 150-ft. tower telescope used for studying the sun, and examined the powerful 75-ft. spectrograph.

By noon the engineers had reached Long Beach. Ralph Reed, chief engineer of the Union Oil Company, spoke briefly on oil-field tools and equipment, after which the oil fields of Santa Fe Springs and Signal Hill were visited.

A more detailed account of the excursions appeared in the May 7th *A.S.M.E. News*, and preceding issues carried descriptions of the engineering achievements at Mt. Wilson and other places visited by the engineers. Those who have had the opportunity to participate in such excursions where demonstrations and explanations are given and close inspection permitted can best appreciate their technical value.

Back in Los Angeles Wednesday evening the meeting closed with a banquet at the Hotel Alexandria, details of which are given on a following page.

Too much credit cannot be given to the committees in charge for the success of this regional meeting. The Regional Committee, Carl C. Thomas, chairman, and the Los Angeles Local Section Committee, George H. Rhodes, chairman, were assisted by committees on local arrangements, with chairmen as follows: finance, J. G. Rollow; professional events, G. H. Rhodes; printing and signs, H. L. Doolittle; entertainment, J. G. Rollow, excursions, Prof. R. L. Daugherty; hotels, H. R. Hilton; information and service bureau, H. L. Doolittle; publicity, R. W. Lawton; and reception, H. R. Hilton.

The Technical Papers and Addresses

Five papers were presented at the technical session held on Monday forenoon, namely, The Oil Venturi Meter, by E. S. Smith, Jr.; Flow of Crowds, by C. H. Benjamin; The Cross-Flow Impulse Turbine, by Forrest Nagler; Diesel-Engine Progress on the Pacific Coast, by H. W. Crozier, John Stigen, and C. E. Nagel; and Hydroelectric Development by the Southern California Edison Co., by H. A. Barre. The papers by Messrs. Smith and Nagler appeared in Mechanical Engineering for May, and the one by Messrs. Crozier, Stigen, and Nagel is printed in the present issue.

Dean Benjamin's paper dealt with the flow of crowds, which he likened to the flow of viscous liquids through pipes. The loss of energy by friction in passages, contracted openings, and bends was similar, and the absence of a pressure head was met by continuing muscular energy. The paper developed a simple formula for the flow. The constants used therein were determined by a series of experiments in a three-story college building with large rooms, halls, and stairways. The crowds (of students) were variously distributed and controlled, and the widths of doorways and stairways were adjustable. It was found that with normal men under control, moving as fast as practicable without crowding, about twice as many could descend stairways and pass through openings of a given width in a given time as had generally been estimated; but it did not follow from this that the old rule should be done away with, for crowds did not always comport themselves as well as those considered in the paper.

Mr. Barre, electrical engineer of the Southern California Edison Co., described the extensive program for power development now being carried out by that organization. This hydroelectric work is chiefly on the San Joaquin River, in the Big Creek district some 240 miles north of Los Angeles, where the conditions are such that it is possible to provide a complete coördinated scheme for the total utilization of the resources of that river—for irrigation as well as for power—in conjunction with the company's other water powers further south and the steam-plant resources which must necessarily accompany any water-power development. In the area under development about 1,400,000 hp. of commercial power is available, and the total cost of the new work involved will be in the neighborhood of $200,000,000. The development comprises two large tunnels, one 5 miles long and 21 ft. in diameter, and another 12 1/2 miles long and 15 ft. in diameter; and several storage reservoirs having capacities of 75,000 acre-feet and upward. When the development is completed the water will have been used through a total head of nearly 6000 ft.

On Tuesday morning, at the California Institute of Technology, Pasadena, R. W. Sorensen, professor of electrical engineering at that institution, described the million-volt 1000 kva. testing set to be installed in its new high-voltage laboratory. There was every reason to believe, he said, that potentials up to this value would be required in the very near future for the testing of standard apparatus used for electric power transmission, and in the meantime the set would be available for use in the investigation of high-voltage phenomena ahead of the commercial demand for high-tension apparatus. The Big Creek system of the Southern California Edison Co., described by Mr. Barre on Monday, had already raised their voltage from 150,000 to 220,000, thus doubling the amount of power they could transmit over their present lines, and many of the tests required by the 220,000-volt apparatus had called for testing potentials of from 450,000 to 500,000 volts. The transformer which Professor Sorensen had designed and which would shortly be installed would consist of four 250,000-volt units, each so constructed that one of its windings could be used to excite another transformer of the series. When the four 250,000-volt windings of these transformers were connected in series with one end grounded, a potential of 1,000,000 volts from line to ground would be obtained. This equipment would at the same time provide the laboratory with a 500,000-volt system with step-up and step-down transformers, four separate 250,000-volt testing sets, or, by use of three transformers Y-connected, a 433,000-volt three-phase transmission line to work with.

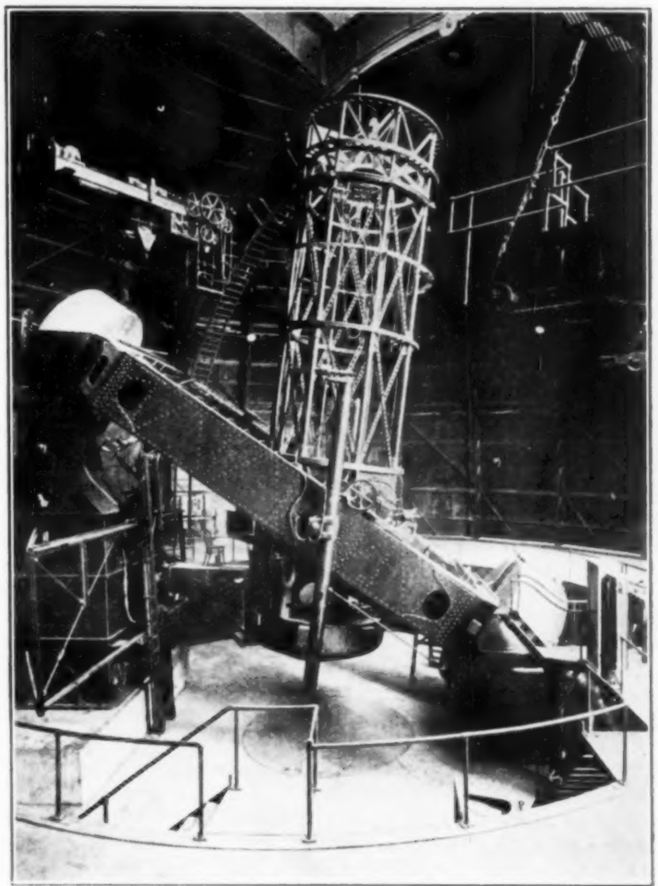
Extended extracts from the address by Professor Pease, referred to in a preceding paragraph, immediately follow.

The 100-Inch Hooker Reflecting Telescope of the Mount Wilson Observatory

The most powerful of all telescopes thus far constructed is the great Hooker telescope of the Mount Wilson Observatory, having a clear aperture of 100.4 in. and a primary focal length of 507.5 in. The telescope is now in actual use, the daily results proving the value of the instrument to be of the highest order.

The Hooker telescope is of the reflecting type wherein a parabolic mirror converges the parallel beam of light coming from the distant object to a focus. The image given is a real image, just as is given by a camera lens; it can be viewed with an eyepiece or photographed by placing a plate at the focal plane.

The mirror is 101.3 in. in diameter, 12 in. thick, and weighs 9000 lb. It is glass, cast in France by the St. Gobain works. Any internal strains likely to alter the curvature are eliminated by mounting the glass on large edge arcs supported on knife edges and supporting it horizontally on 12 pads, three of which are fixed, the remaining 9 counterweighted. The glass and its supporting systems lie in a massive steel cell which bolts to the lower end of an open tube 11 ft. outside diameter and 38 ft. long. The bottom section of the tube is composed of steel-casting rings, columns triangular in cross-section, of pressed-steel plates, and open panels of steel plate. Two massive castings are built into the section to carry the declination trunnions. The remaining sections, including the "cages" which carry the various auxiliary mirrors, are built of similar steel rings, columns of Shelby tube, corner castings of steel and diagonals of tire channel. Each section is assembled and then machined as a unit; the cages are interchangeable, fit a tapered ground point on the upper end of the permanent part of the tube and are locked in position by 8 lip bolts controlled by a single handle.



Interior View of Dome, Mt. Wilson Observatory

The weight of the tube is 35 tons; its center of gravity lies on the declination axis, so that it is always in balance. As some of the various attachments alter this balance, the change in moment is compensated for by the motion of two 1400-lb. weights in the large tubes at the side. Two additional counterweights are placed under the mirror cell to provide for adjustment about the axis of the tube.

The declination bearings are spherical in shape to allow for any flexure of tube or yoke; these spheres serve to align the axis while the bulk of the weight at each bearing is taken up by two systems of roller and ball bearings, one axial, the other radial; these systems are counterweighted by a series of levers extending downward along the yoke and actuated by a common weight.

The tube is suspended in a massive yoke, the polar axis, 16 ft. across and 32 ft. long, on the ends of which are trunnions supported by massive bearings. The axis of the yoke lies parallel to the earth's axis and is inclined at an angle of 34 deg. 13 min. to the horizontal, pointing to the north pole of the heavens.

The yoke consists of four members, built of structural steel with a massive steel casting at each end; their weight is 10 tons each and after assembling each was machined as a unit. Their average cross-section is 2 ft. wide by 4 ft. deep; hollow steel trunnions are bolted on the end members, and to these in turn are bolted the large steel flotation drums. The weight of the moving parts of the telescope is 100 tons. This mass is driven at just such a rate (1 revolution in 24 hours) as to equalize the diurnal motion of the earth, consequently every provision is made to reduce friction to a minimum. To define the polar axis there are two spherical bearings, and to relieve the friction two liquid flotation systems, consisting of hollow steel drums fastened to the trunnions, which float in tanks of mercury supported by the north and south pedestals. The drums are bolted at their upper ends and their insides relieved about an inch so that sleeves fastened to the south faces of the

tank reach nearly to the upper faces of the drums, thus increasing the depth by many inches. The south drum displaces 60 tons and the north 40 tons. There is a ball ring thrust bearing at the lower face of the south bearing to define the position of the axis longitudinally. The instrument is driven by a "driving clock" through a worm and worm wheel which clamps to the south trunnion.

Rapid motions are provided for setting the telescopes in right ascension and declination as well as slower motions to enable the observer to correct for errors in speed, refraction and bad seeing.

The worm wheel, which is 200.53 in. in diameter, has 1440 teeth accurately cut on the circumference and so ground that there is no periodic error as great as 0.00001 in.

The driving clock connects directly to the worm with a double Hooke's joint to eliminate any periodicity due to the worm and clock shaft not being truly adjusted. The speed of the worm can be altered by the observer by means of a motor mounted on the last shaft of the clock. The declination, quick, and slow motions are mounted on the yoke beside the tube and operate on it, the former through a sector, the latter through a long screw and arm. The range given by the two motions is from 30 deg. to $2^2/_3$ min. arc per minute of time.

The telescope stands on a hollow concrete pier 33 ft. high, bringing the intersection of the polar and declination axes at elevation 50 ft.

Since variation in temperature alters the figure of the mirror with consequent distortion of the image, the mirror and its cell have been surrounded with an inch of corkboard and means provided to control the temperature within the enclosure. Brine, the temperature of which is automatically controlled by a thermostat within the enclosure, is circulated from a tank in the pier through coils lying under the mirror; fans circulate the air all around the mirror and coils. The brine is heated by electrical coils in the tank and cooled by ammonia expansion coils. Eight interconnected leaves, motor-operated, fold open in front of the mirror when in use.

The housing is a dome 100 ft. in diameter and 100 ft. high, all above 28 ft. rotating on tracks on the lower fixed part. The dome is of structural steel and sheathing throughout, and double-walled to insure more uniform temperature inside. The upper part is carried on 28 trucks with conical wheels and is traction-driven by two $7^1/_2$-kw. motors at opposite points. Its weight is 550 tons, while that of the fixed part is 250 tons. A slot 20 ft. wide extends from elevation 44 ft. to the peak of the dome, providing an opening through which the telescope is pointed, and is covered with a shutter formed by two halves moving along horizontal tracks.

To reach the primary focus of the telescope an observing platform is placed across the shutter opening, which travels up and down the main girders, its level being automatically regulated at the hoisting drum. To reach the secondary or Cassegrain focus on the north side of the tube, there is a platform which travels across and up and down the south face of the north column.

All motions of the instrument and dome are motor-driven and nearly all the circuits are "remote control." The settings can be made from a deck just beside the south pedestal and from auxiliary controls at the three foci. There are altogether 40 motors used in the dome, with an aggregate of 50 hp., and about 14 miles of wiring.

A 10-ton crane travels along the main girder opposite the shutter opening and handles all cages and instruments about the telescope.

The telescope is situated upon Mount Wilson near Pasadena, California, 5800 feet above sea level, where the atmosphere is free from the lower clouds and dust and where it can be operated a large part of the year to excellent advantage.

Looked on as an engineering problem, no serious difficulty was met with in the construction of the Hooker telescope, and a machine of double the aperture might well be built before one was seriously at the limiting factors of the materials of today.

Speakers at the Banquet

The banquet with which the regional meeting closed gave those attending it an opportunity to meet and hear speak a number of the men who have done much to advance the engineering profession, either in California or other sections of the country. Carl C. Thomas, as chairman of the Committee on Arrangements, made the address of welcome and introduced the toastmaster of the evening, John A. Britton, first vice-president and general manager of the Pacific Gas & Elec. Co., of San Francisco.

The welcome of the city of Los Angeles to the Society and its guests was expressed by Captain John D. Fredericks, past-president of the Chamber of Commerce of Los Angeles, and C. E. Cook, now head of its publicity department. Captain Fredericks, an eloquent speaker, voiced the praise and love of many for the Pacific Coast. "Out here," he said, "where the Pacific has been singing the sunset song of the nation for a great many years, we have learned that it is a wonderful place to live and a wonderful place to dream; but we have also learned that it is a wonderful place to work." He called attention to some of the great engineering feats that have been accomplished and some yet to come. He referred particularly to the protection of the Imperial Valley from the flow of the Colorado, and to the reclamation of some two million acres of unproductive land lying just back of it, and to the building of a great harbor for Los Angeles.

Mr. Cook, who personally conducted the first excursion of the A.S.M.E. to California, back in 1892, described that trip and similar ones, for other groups.

John Lyle Harrington, president of the Society, spoke of the difficulties which engineers have had to overcome in developing California and urged that the strength, the knowledge, experience, and idealism which have been gained thereby be contributed in ever greater measure to the upbuilding of a unified engineering profession. He urged also that the engineer participate more largely in the business and government of the country, stating emphatically that "it is highly essential that the engineer come to take more than a technical part in the work of the development of the nation."

Dr. Ira N. Hollis, past-president of the Society, who recently resigned the presidency of Worcester Polytechnic Institute, a follower for many years of the sea, used a number of his stock of sea stories to drive home the importance of the solidarity of the engineering profession. He spoke briefly of the ties which bind the states of the Union together and praised the engineer for the part he has played in establishing these ties, and for his achievements in other countries, particularly in Egypt. He disagreed with those who feel that the engineers are praising their profession too much, because "it is pride in our profession that will enable us to do the best work."

The growth of the manufacturing industries of Los Angeles was surveyed by Henry M. Robinson, president of the First National Bank of Los Angeles. He believed that her possibilities as a point for assembling raw materials for manufacturing and distribution to the Atlantic seaboard cities were very great. He referred specifically to cotton, copper, pig iron, and steel.

R. H. Ballard, vice-president and general manager of the Southern California Edison Co., pictured what prosperous public utilities mean to communities, and discussed the share of the communities in making their utilities prosper. "The prosperity of any section," he said, "depends upon having a good, active, energetic, and prosperous public utility or a number of utilities." He discussed the ownership and regulation of public utilities, pointing to the advantages of private ownership with public support, the method now in general practice.

William Mulholland, chief engineer of the Bureau of Water Works and Supply of Los Angeles, spoke of the responsibility of the engineering profession as an agency in the advancement of man. "Every step in the progress of man," Mr. Mulholland said, "is marked by his ability as an engineer. All the implements or early instruments that go back to the earliest history of mankind, are evidences of his ability as an engineer. The advancement of man parallels the development of tools."

D. W. Pontius, vice-president and general manager of the Pacific Elec. Ry. Co., spoke briefly on interurban transportation. He discussed the enormous amount of traffic in California and the steps being taken to handle increasing traffic in the future.

The final speaker, Dr. Robert Sibley, who for years has closely followed hydroelectric developments, particularly on the Pacific Coast, gave an illustrated lecture on the subject, which was of great interest to his listeners. It is planned to publish his address in the August issue of Mechanical Engineering.

Fluctuations in Student Enrollment in Engineering Courses

Data Furnished by Twenty-One Typical American Universities and Colleges Show Trends in Interest in Engineering Education During Past Ten Years

MANY engineers and educators are of the opinion that the interest in engineering as a profession varies with the commercial prosperity as well as with the normal growth of the country. Educators have reached the conclusion that the scholastic mortality of engineering students is high. The first of the above conditions would appear to be a natural sequence of human events; the second would indicate an error in choice by the student, a lack of sufficient and sound preparation, or a faulty program.

In order to determine conditions and trends in interest in engineering and in the mortality in engineering courses, comprehensive enrollment figures of engineering students in twenty-one American colleges, universities, and institutes have been secured, the institutions being selected with due respect to geographical distribution. The data were collected and this report prepared by Alan Bright and W. F. Rittman, registrar and professor of commercial engineering, respectively, of the Carnegie Institute of Technology.

Fig. 1 (*a*) shows the numbers and changes in total enrollment of engineering students in the twenty-one institutions under consideration. It is frankly recognized that these total numbers fall far short of the total enrollment of students in engineering in America. It is believed, however, that the trend is definitely in harmony with that of the entire country. The curve clearly shows that during the world war and immediately following, the number of engineering students increased at a rate unprecedented

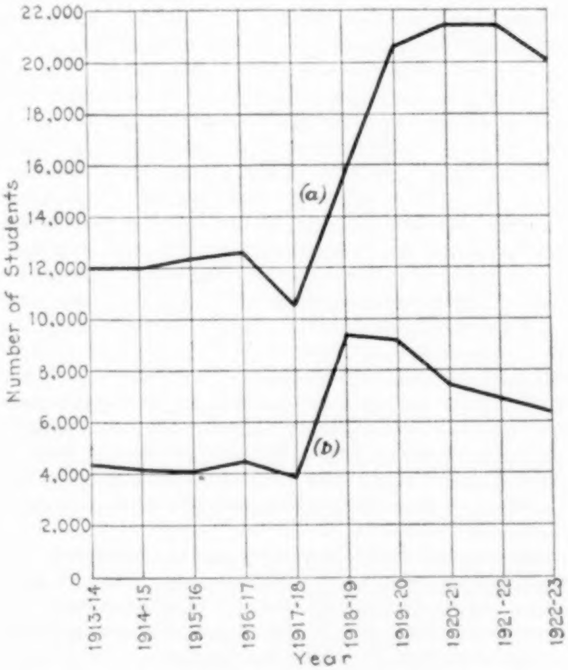


FIG. 1 TOTAL ENROLLMENT (*a*) OF ALL STUDENTS AND (*b*) FRESHMEN IN 21 ENGINEERING SCHOOLS, 1913–1922

theretofore and reached a maximum in 1920. The 1920 enrollment is nearly 80 per cent greater than the somewhat constant registration existing in 1913 and 1914.

Fig. 1 (*b*) shows the numbers and changes in freshman enrollment of engineering students of the institutions. It is believed that this curve shows the attitude and changes in attitude of the general public toward engineering as a profession. The world war appears to have given a tremendous impetus to public interest in the study of engineering. This impetus is very probably the result of the fact that modern warfare is almost entirely a matter of applied engineering in all its branches. Never in the history of the world were engineers of greater importance and in greater demand than during the period from 1915 to 1920. The dropping off in the enrollment of freshman engineering students from 1919 to 1922 was but a natural reaction from the abnormal increase of 1918 and 1919, aided by the industrial depression of 1920 to 1922. Added to these conditions there was a decreased demand for engineers. These figures, also, are not absolute totals for the country, but it seems evident that they do definitely represent trends.

Fig. 2, expressed in terms of percentage, show the ratio of engineering freshmen to seniors. These percentages vary from as high as approximately 80 per cent to as low as approximately

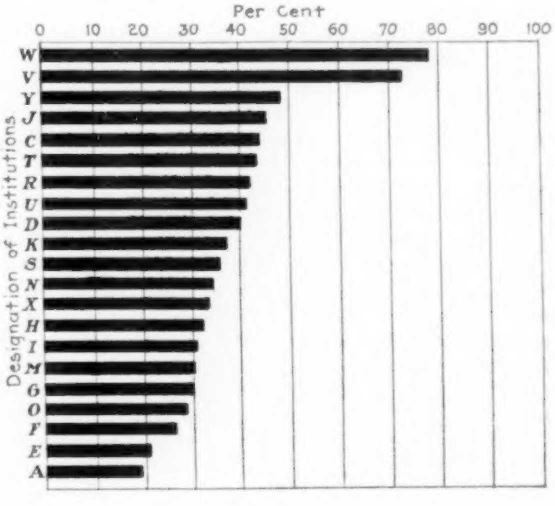


FIG. 2 RATIO (EXPRESSED IN PERCENTAGE) OF SENIORS TO FRESHMEN IN 21 ENGINEERING SCHOOLS, 1913–1922

20 per cent of those who enter as freshmen and who remain until their senior year.

Certain institutions receive a large percentage of their upper-class students from the academic colleges who register with advanced standing. As a matter of economy many students, especially in the Middle West, prefer to attend an institution near home for one or two years and then enter a more distant engineering school, even at the expense of spending five years in college. It is not infrequent that heads of engineering schools urge those who can afford it to graduate from an academic college before entering an engineering school. This tendency accounts for the lower mortality in the upper years at certain institutions.

TABLE 1 AVERAGE CLASS ENROLLMENT IN ENGINEERING COURSES IN 21 TYPICAL INSTITUTIONS, 1913–1922

Institution	Freshmen	Sophomores	Juniors	Seniors
W	525	504	471	412
V	157	141	131	114
Y	222	163	128	108
J	298	228	178	136
C	351	245	211	156
T	310	207	157	136
R	224	136	111	99
U	187	134	105	80
D	120	81	60	48
K	551	365	253	205
S	231	163	107	85
N	396	307	199	138
X	161	99	75	56
H	173	87	56	58
I	582	258	233	180
M	370	251	163	112
G	143	80	53	43
O	320	189	115	93
F	304	187	103	81
E	173	108	57	37
A	270	139	82	53
Average	289	194	145	117

Table 1 gives the average number of students, during the years 1913–22, in each of the 21 institutions under observation, and the averages for them all, from which the percentages of loss may be easily computed.

Meetings of Other Societies

American Institute of Electrical Engineers

The operation, control, and protection of transmission and distribution systems was selected this year by the American Institute of Electrical Engineers as the keynote of its spring convention, held in Pittsburgh, Pa., April 24–26, 1923. Of the five technical sessions, including in all some twenty papers and a good deal of valuable discussion, one on the morning of the second day of the convention held the greatest interest for mechanical engineers.

Three of the papers at this session dealt with electric-furnace problems. F. V. Andreae, chief engineer for the Southern Manganese Corpn., Anniston, Ala., stated his belief, formed after careful observation of electric-furnace operation, that the transformation of electrical energy into heat energy in the furnace takes place in an arc passing through an atmosphere of vapors under pressure. He derived a general equation for the three-phase furnace and took up specific examples of its application, showing how the unbalance can be taken care of in several ways. His final conclusion was that the general performance of the three-phase furnace can be determined in advance with a high degree of accuracy by using the simple equations of the balanced three-phase system, where the only thing that is necessary is the previously determined reactance per phase.

A paper by Frank Hodson, president of the Electric Furnace Construction Co., dealt with the development of the large electric melting furnace, the limitations of large electrode furnaces, and the design and construction of the 80-ton furnace at the Ford River Rouge Plant. The advantages of correct heat application, the influence of the new Soderberg continuous electrode on furnace design, and the possibility of using large electric furnaces as an intermediate process for the manufacture of cheap steel were other subjects discussed by Mr. Hodson. The new Soderberg electrode to which he referred consists of a thin metallic casing the size of the electrode to be used, into which the electrode paste or mix is dropped. The actual baking of the electrode is done in the furnace.

The other paper on electric furnaces was by A. N. Anderson and B. D. Saklatwalla, both of the Vanadium Steel Corpn. It discussed electrical factors to be considered in the design of leads for ferroalloy electric furnaces in order to achieve the highest input efficiency.

At the same session A. H. Babcock, electrical engineer for the Southern Pacific Railroad, presented a paper on Some Fuel Determinations on the Southern Pacific System, and C. T. Guildford, of the Westinghouse Elec. & Mfg. Co., one on Heating a Cotton Weave Shed by Electricity. Mr. Babcock gave test data on a representative mountain railway on the West Coast showing the fuel consumption of an average mountain-type locomotive burning oil, beginning with firing up at the engine house and including consumption while testing brakes, during acceleration, running up and down various grades, holding the trains on sidings, and finally running down hill over stretches of steep grade. The overall efficiency determined by the test was 5.57 per cent, but the author stated that the data apply only to the specific conditions and should not be applied indiscriminately to all conditions of operation.

Mr. Guildford described the electric heating system at the St. Croix mill of the Canadian Cottons Co., Ltd., Milltown, New Brunswick, Canada, which operates nearly 57,000 spindles and over 1400 looms, and told how to estimate the quantity of heat required for such buildings. The method of heating employed at the St. Croix mill is the Sturtevant hot-air system with groups of electric heating units instead of steam coils in the fan room. The weave shed, which is a one-story building 480 ft. long by 180 ft. wide, requires 1600 kw. consumption at 15 deg. below zero. Electric heat may be adopted with economy in mills where surplus hydroelectric power is available. To be on a parity with coal at $10.50 per ton, the electric heat should cost $0.0025 per kw-hr. where the average heating-season temperature is 22 deg. In the case of the plant at Milltown a return of more than 37 per cent on the investment for the electrical equipment is shown.

Subjects discussed at other sessions of the convention were grounding devices, the technical features of surges and arcing grounds, relay schemes and illumination, reactors, lightning disturbance, and insulators.

American Welding Society

A comprehensive program, reviewing progress in all the phases of welding, was presented at the annual meeting of the American Welding Society, held in New York, April 24 to 27. The majority of the sessions were devoted to committee reports, only two including the presentation of papers.

Four speakers summarized new developments in the welding field, as follows: W. L. Warner, General Electric Co., Schenectady, N. Y., Electric Welding; G. O. Carter, consulting engineer, Linde Air Products Co., New York, Gas Welding; Hermann Lemp, General Electric Co., Erie Pa., Resistance Welding; and J. H. Deppeler, chief engineer, Metal & Thermit Corpn., Jersey City, N. J., Thermit Welding.

Mr. Warner reviewed the work of the American Bureau of Welding, which is the welding research department of the American Welding Society. Standard tests for welds and welding-wire specifications have been made and a large amount of general research work carried on. Enumerating some interesting applications of the welding process, Mr. Warner spoke of hammer forging as being highly valued for improving the strength, ductility, and fatigue resistance of metal deposited by the electric arc. High welding currents are now being used, he stated, 300 amperes sometimes being employed with coated electrodes for large thermal capacities, and the arc welding of brass with a flux-covered type of copper electrode is already commercial in England. Malleable-iron welds, although possible and sometimes necessary, are not sufficiently strong to justify frequent use. Mr. Warner stated that arc welding has been found economical for the repair of machinery in steel mills, and that the arc welding of monel metal is possible when the proper reducing flux is used. Referring to arc-welding apparatus, the speaker described a safety switch which cuts the power from the welding line and primary circuit whenever the arc is not being drawn. The voltage at all times during welding is limited to a harmless value.

The welding of long stretches of steel pipe was emphasized as an outstanding feature of the past year by Mr. Carter, who gave details of a 140-mile line of 8-in. pipe welded by the Prairie Pipe Line Co. There are three intermediate pumping stations and the line has been welded into a continuous tube from one station to the other, no coupling joints being used. The line carries 750 lb. maximum oil pressure. Mr. Carter suggested the welding of the barrels of concrete mixing machines instead of the usual riveted instruction, outlined the further extension of oxy-acetylene welding to maintenance and repair work, and reported that many valuable applications of the oxy-acetylene process of cutting cast iron have been made. The correct methods of handling cast-iron welding, however, are not so well known.

Mr. Lemp, outlining developments in resistance welding, said that the progress has been made in extending the application of the process with existing apparatus. Among the newer applications which he mentioned were the successful welding of the halves of steel castings and forgings, the welding of cast-iron valve heads to steel shanks, and the welding of tungsten and copper cable for radio apparatus.

The fourth speaker, Mr. Deppeler, gave the results of a research to eliminate blowholes in steel, which is accomplished by permitting the gases to escape through the molds. He also spoke of developments in the rail-welding field and described a new and more efficient design of preheater recently developed.

At a second technical session Dr. H. L. Whittemore, of the Bureau of Standards, Washington, D. C., outlined the method and results of tests made by the Bureau on unfired pressure vessels. These tests were conducted in coöperation with the pressure vessel committee of the American Bureau of Welding for the information of the A.S.M.E. Boiler Code Committee, which is now working upon a code for the construction of unfired pressure vessels. A hydrostatic and hammer test was used and 40 tanks have been tested to the point of destruction. The shells of most of the tanks were 6 ft. long by 2 ft. in diameter and made of $^3/_8$-in. mild-steel plate. Both electric and oxy-acetylene welding were used. It was found that the welded pressure vessel, according to the regular formula for working pressure, has a factor of safety of about 6. The results of the tests are now in the hands of the Boiler Code Committee.

At the same session J. C. Wright, of the Federal Board of Vocational Training, chairman of the committee on training of welding

operators of the American Bureau of Welding, explained a training course for oxy-acetylene welders developed by his committee. The analysis of the work of an oxy-acetylene or gas welder presents various types of jobs with a statement of the operations necessary to perform each, and the information and skill which the operator must possess in order to be an efficient worker.

American Foundrymen's Association

For the third time in its history the American Foundrymen's Association selected Cleveland for its annual convention. The first of its meetings there, which was also the occasion of its first official exhibition of foundry equipment and supplies, took place in 1906; the second occurred ten years later; and the third, which was the 27th annual meeting, in conjunction with the 17th exposition, was held April 28 to May 4, inclusive.

A commendable feature of the technical program was the great reduction in the number of papers presented, as compared with previous conventions, permitting more extensive discussion and promptness in closing sessions. The business session was brief. The election of G. H. Clamer as president to succeed C. R. Messinger was announced. Mr. Clamer is first vice-president and general manager of the Ajax Metal Co., Philadelphia, and is well known not only for his work as a non-ferrous metallurgist but also for his investigations of alloys and inventive work in connection with electric furnaces. Mr. Messinger, the retiring president, Dr. George K. Burgess, newly appointed director of the Bureau of Standards, and Dr. H. Ries, of Cornell University, were elected honorary members of the association in recognition of their services to it.

There were two joint sessions with the Institute of Metals Division of the American Institute of Mining and Metallurgical Engineers, both on the subject of non-ferrous foundry practice. A feature of the first, held on April 30, was the presentation of the annual exchange paper from the Association Technique de Fonderie. In the absence of the author, M. de Fleury, Mr. Clamer read the paper, which was on the application of the aluminum alloy alpax in the foundry. Alpax was described as being an alloy of aluminum and silicon which when treated with certain alkaline salts is said to have unusual properties. Because of its lightness, strength, and low coefficient of expansion and contraction it has been developed for automotive parts particularly, being used for cylinders, pistons, and connecting rods. Other properties and uses of the alloy were also discussed. Emile Ramas, president of the Association Technique de Fonderie and director of the Société Francaise Metallurgique, was a guest at this session and spoke briefly.

R. J. Anderson, of the U. S. Bureau of Mines, Pittsburgh, Pa., was another prominent figure at these joint sessions. At the first he presented a paper on the linear contraction and shrinkage of light aluminum alloys, giving results of a series of experiments at the Bureau to obtain data for use in making pattern allowances. The linear contraction was found to vary between 0.95 and 1.80 per cent. He was also co-author of two papers presented at the second joint session. One gave additional data secured by the Bureau of Mines, dealing with the linear contraction of brasses and bronzes, showing that in general high-temperature pouring causes less contraction than low-temperature pouring. The other discussed the effect of heat treatment on release of stress in bronze castings. E. G. Fahlman, National Smelting Co., Cleveland, and C. L. Eldridge, Metropolitan Museum of Art, New York, were respectively co-authors of these papers.

Among other papers presented at this session was one by F. L. Wolf and W. Romanoff, Ohio Brass Co., Mansfield, Ohio, abstracted by Dr. Paul D. Merica, International Nickel Co., New York. It discussed various shop problems encountered in making castings of brass and bronze, and gave data on pouring temperatures, furnaces, properties of castings, fluxes, etc. It was concluded that the pouring temperature should be as low as possible, consistent with the sizes of the castings.

There were also two sessions on steel foundry practice. Major Minton, U. S. Ordnance Dept., Watertown Arsenal, Watertown, Mass., dealt with the production of links and grousers for army tractors. The physical and chemical properties which these castings must have was given and their heat treatment described. Slides depicted the method in use at the Watertown Arsenal for testing these castings.

A paper illustrated by slides and a motion picture showed a process for the centrifugal casting of steel developed by William McConway, of McConway & Torley, Pittsburgh, Pa. The paper was presented by Harvey Allen of the McConway company. The steel is cast, revolved under hydraulic pressure until it is solidified, conveyed to the soaking pit, and then broken down on the forging presses to produce various sections.

H. A. Lorenz, Bucyrus Co., South Milwaukee, Wis., brought out the fact that the heat treatment of steel castings emphasizes the good and bad qualities of the original casting. He mentioned particularly the bad effects of non-metallic inclusions, dendritic structure, and improper density. He presented data on heat-treating practice on chrome-nickel-steel castings and recommended further research on special alloy steels.

An investigation to determine specifically the proper thermal treatment to apply to electric steel castings of 0.20 to 0.32 per cent carbon was described by H. A. Neel, Michigan Steel Casting Co., Detroit, Mich.

Several papers on gray iron were presented, one of particular interest to mechanical engineers being on gray iron for automotive castings, by H. B. Swan, Cadillac Motor Car Co., Detroit. It contained the results of a questionnaire sent to twenty-five automotive-castings plants, giving data on iron mixtures and cupola practice in producing cylinders, pistons, crankcases, and various small castings. The author reviewed the effects of carbon and other elements upon the physical properties of automotive castings, and commented upon the lack of standard cupola practice and of tuyere ratios.

At a session on malleables a paper by E. D. Smith, Lakeside Malleable Co., Racine, Wis., read by E. J. Lowry, of Hickman, Williams & Co., Chicago, showed that there are great possibilities in hardening and tempering malleable castings. It described experiments conducted to determine the feasibility of hardening malleable-iron parts, the nature of the hardened product and the processes best adapted to hardening, and suggested further fields for research on this subject.

Other papers at this session dealt with the application of fuel oil to the malleable air furnace, describing furnace construction and methods of operation which have been successful; the adaptation of continuous tunnel annealing furnaces to the malleable-iron industry, with details as to the construction, operation, and control of the furnaces; and a method for reducing the amount of scrap in a malleable foundry.

Two sessions on sand research, reclamation, conservation, testing methods, and geological survey work were of great interest to members interested in these phases of foundry work. Several committees reported, bringing out considerable discussion, and a number of papers were presented. Much of the discussion centered about methods of determining the bonding strength of molding sands. Dr. Ries described experiments at Cornell based on the Doty method, but with a different process of ramming the sand specimen.

Industrial engineering, dealing principally with employment, cost accounting, foreman training, compensation, and apprentice ship courses, has in recent years received considerable attention at the foundrymen's meetings. This year the subject of industrial education was presented for discussion in the form of a symposium of eleven papers on training foundry workers. The speakers represented not only state and educational institutions but also manufacturers who have inaugurated foundry courses. It was the consensus of opinion that the successful apprentice course must be based on a policy to give thorough training to the apprentice, and at the same time afford a sufficient monetary reward during the period of apprenticeship.

Two sessions characterized as dealing with new developments in the foundry industry complete the technical sessions. Leon Cammen, associate editor of Mechanical Engineering, traced the history of centrifugal casting and outlined its possibilities. He explained the mechanics of centrifugal casting on horizontal, vertical and inclined axes respectively, and touched upon the temperature of mold surfaces, comparing warm molds, water-cooled, and hot molds. The process of hot-mold centrifugal casting, which he himself has devised, he said makes possible the production of thin sections $^3/_{16}$ in. and up in considerable lengths

and in comparatively small diameters. Heating the mold to a high temperature obviates the rapid chilling of metals that results when they are poured at temperatures only a little above the melting point. It has been found that a $^3/_{16}$-in. wall of steel poured against a mold having a temperature of 1700 or 1800 deg. fahr. takes about 45 sec. to harden completely, which is sufficient to produce clean metal. Becket metal analyzing 0.50 per cent carbon, 26 to 28 per cent chromium, 0.40 to 0.60 per cent silicon, and 0.60 per cent manganese is most suitable for the hot molds, and for best results the surface of the mold should be lapped as smooth as glass.

Dr. Richard Moldenke, Watchung, N. J., presented a paper at each of these sessions, one on the desulphurization of cast iron, in which he discussed various methods for reducing the sulphur content of iron, and one on the development of a new long-life mold. G. K. Elliott, The Lunkenheimer Co., Cincinnati, spoke on gray cast iron from the point of view of the electric furnace, outlining the main features of the acid and basic electric furnaces and then sketching the general operating features of both the cupola and the electric furnace. The manufacture of synthetic foundry iron in the electric furnace was discussed in a paper by C. E. Sims, C. E. Williams, and B. M. Larsen, all of the Northwest Experiment Station of the U. S. Bureau of Mines, at Seattle, Wash. They described the production of cast iron from almost any kind of ferrous scrap by the use of a carburizer. They recommended a dense, pure form of carbon for the carburizer and stated that this should be charged under the metal and the melting conducted from the bottom up.

Recent developments in British foundry practice were summarized in a paper by Dr. Percy Longmuir, director of research for the Institution of British Foundrymen. This paper was the annual international exchange paper contributed by the British foundrymen and may be characterized as supplementary to addresses by Dr. Longmuir before the A. F. A. over twenty years ago, in which he declared that the future of all foundry work depended upon the development of scientific methods. His paper, read by Mr. McPherran of the Allis-Chalmers Mfg. Co., showed how the growing use of such methods is making the British foundrymen more efficient.

An extensive exhibit of foundry supplies and accessories was held simultaneously with the convention at the new Auditorium. This exhibit deservedly attracted the attention of the foundrymen present, and was of considerable interest in many ways. While it did not show any striking new developments or sensational improvements in machinery, it went along way toward proving the high state of the development of the mechanical accessories now at the service of the American foundryman.

There were numerous exhibits of material-handling equipment, the demand for which is rapidly growing with the increasing scarcity of labor, as well as of sand mixers, molding machines, crucibles, welding apparatus, heating and small melting furnaces, etc.

American Electrochemical Society

The annual spring meeting of the American Electrochemical Society was held in New York, May 3 to 5, 1923, under the auspices of the New York section. A symposium on the production and use of rare metals was the main feature of the convention. Dr. F. M. Becket, Carbide & Carbon Co., New York, who secured the contributions, was presiding officer and opened the meeting with an address on an investigation conducted by the research department of his company under his direction to determine the effect of zirconium in steel. It presented some revolutionary facts, made public for the first time, showing the definite effects of the use of a silicon-zirconium alloy in the production of steels of various kinds, among which may be mentioned its scavenging and desulphurizing properties, as well as a remarkable effect which it has on the rolling properties of steel when the actual sulphur content is high.

One of the important papers of this symposium was descriptive of experiments with rare-metal steels using uranium, boron, titanium, zirconium, cerium, and molybdenum, by Dr. H. W. Gillett and E. L. Mack, of the Bureau of Mines, Ithaca, N. Y. A large protion of the paper was devoted to a discussion of molybdenum in steel. Molybdenum was said to be a real alloying element and more potent in its effect than any other element, except possibly carbon. Attention was called to the air-hardening properties, particularly the depth thereof, which molybdenum bestows upon steel, and to the changes which it brings about in the critical range, an effect which vanadium does not have. Dr. Gillett, who presented the paper in abstract, stated as his belief that the presence of molybdenum in steel results in good strength combined with extra good ductility.

The present status of the production of rarer metals, the effect of alloying elements in steel, the preparation of metallic uranium, and platinum metals were other subjects included in the symposium.

Miscellaneous subjects were covered at other sessions, among them being heat-insulating materials for electrically heated apparatus, methods of handling materials in the electric furnace and the best type of furnace to use, electric-furnace detinning and production of synthetic gray iron from tin-plate scrap, and a new process called "chromizing," analogous to calorizing and sherardizing. F. C. Kelly, who is connected with the research laboratory of the General Electric Co. at Schenectady, N. Y., described this process, which involves the introduction of chromium at temperatures above the ordinary into the surface of iron, forming more or less of a superficial alloy or covering. He stated that chromizing may be used to prevent the flow of a metal like copper on iron at a temperature above the melting point of copper, as well as to prevent corrosion.

Important to A.S.M.E. Members Interested in Stress Analysis

AT THE 1922 Annual Meeting, under the auspices of the Railroad Division, an extremely valuable paper dealing with stresses in locomotive frames was presented by R. Eksergian. The paper gives a lengthy and complete discussion of the analytical methods to be followed in determining stresses in locomotive frames.

In view of the fact that there was a great wealth of material presented at the last Annual Meeting and that the Committee on Publication and Papers was compelled to reduce the size of Transactions to the minimum, it was decided to omit Mr. Eksergian's paper from the annual volume, but to print pamphlet copies of the complete paper with the discussion on it, and supply copies to members who might desire to have them. The number of copies printed will be limited to the number of requests for it received before September 1. Requests for this pamphlet should therefore be sent to the Secretary's office before that date.

A synopsis of the paper follows. Members of the Society are requested to study this carefully and determine whether the subject-matter would be of value in their work. It may be stated that the analytical methods developed by Mr. Eksergian should prove of value to all engineers engaged in the study of stresses howsoever set up.

Synopsis of R. Eksergian's Paper on Stresses in Locomotive Frames

This paper is essentially a preliminary analysis of the major reactions brought on a locomotive frame, as well as of the nature of frame action as regards variation of bending moment, shear, etc. for differently supported types of frames.

A careful analysis has therefore been made of the various methods of equalization, spring design, and the nature of cab supports in electric locomotives. This is followed by a section dealing with the dynamics of the steam locomotive, where the variation of torque and a quantitative investigation of the various oscillations are discussed in detail. Further, a careful analysis of the variation of side-rod loads and journal-bearing loads is included. The succeeding section deals with electric-locomotive drives and the major reactions brought on the frame. This section includes the dynamics of the electric side-rod drive, which discussion augments the previous one on side-rod loads in steam locomotives. The next section discusses the dynamics of braking, its change in load on the equalization, and the reactions brought on the frame. In this section is included a brief discussion of bumping loads and dynamical loads on the drawbar.

For a more quantitative investigation of the effects of vertical loads the bar frame has been approximately treated as a continuous beam under equalizer-applied loads and boiler supports, and the variations of bending shear, etc., for the U. S. Standard Pacific locomotive are computed in detail in Appendix No. 1. Following this is a careful analysis of the stresses resulting from longitudinal loads due to traction, etc.

Finally, the nature of the lateral reactions and the dynamics of lateral oscillations on entering a curve, etc., are discussed, a short recapitulation of the static reactions while on a curve being also given.

A brief outline of methods of analysis coördinating with future experimental work is discussed in Appendix No. 2

Engineering and Industrial Standardization

The Lumber-Standardization Program

AT THE first American Lumber Congress, in 1919, steps were taken to inaugurate simplification and general standardization of lumber sizes and grades. Since that time the Engineering Bureau and the Bureau of Lumber Economics of the National Lumber Manufacturers Association, at the request of the American Lumber Congress, have been continuously engaged in a thorough study of lumber standards.

The lumbermen of the United States have assumed the responsibility of establishing and maintaining the lumber trade upon a high plane of efficiency and of ethical practice, and to accomplish this they have established the "Central Committee on Lumber Standards," representing the entire organized trade from producer to consumer and created by a general conference of lumber manufacturers, distributors, and consumers in July, 1922. This Central Committee on Lumber Standards is composed of

John W. Blodgett, *Chairman*, representing National Lumber Manufacturers Association
W. E. Hawley, *Vice-Chairman*, representing the Association of Railway Executives, and the construction engineers
John H. Kirby, representing the Southern Pine Association
Chas. A. Goodman, representing lumber manufacturers
Dwight Hinckley, representing American Wholesale Lumber Association
John E. Lloyd, National Retail Lumber Dealers Association, representing lumber retailers
Sullivan W. Jones, representing the American Institute of Architects
W. L. Saunders, representing lumber manufacturers.

Its declared function is to act as a steering organization to draft and submit to its constituent associations its best judgment of suitable ways and means to accomplish in practice the simplification of lumber grades; the standardization of lumber sizes, the certification of quantity and quality, and the enforcement, by means of association inspection service and, if practicable, by grade marking of definite standards of lumber sizes and grades.

The National Lumber Manufacturers Association with which, prior to the appointment of the Central Committee, the initiative in further development of the standardization program had been lodged by the lumber trade, turned over to the Committee the results of its three-year investigation of lumber standards, together with an outline of definite proposals for the Committee's consideration. These were made the basis of the suggestions for lumber standards now being submitted by the Committee to the lumber industry.

One of the first acts of the Central Committee was to arrange for the establishment and maintenance of permanent headquarters and offices in Washington, D. C., under the direct charge of R. C. Merritt, who it appointed to be its executive secretary. Its next important act was the creation of the following Consulting Committee to prepare in behalf of its constituents appropriate data and suggestions for the consideration of the Central Committee:

Wilson Compton, *Chairman*, National Lumber Manufacturers Association

Group Chairmen

George Gerlinger, representing manufacturers
W. T. Murray, representing manufacturers
Harry J. Meyers, representing retailers, Brown-Borhek Lumber & Coal Co.
C. V. McCreight, representing wholesalers, Ricks-McCreight Lumber Co.
C. E. Lindsay, representing railroads, New York Central Lines
Wm. A. Babbitt, representing wood-using industries, National Association of Wood Turners, Inc.
E. S. Hall, representing architects and general contractors, American institute of Architects
Dr. Hermann von Schrenk, representing engineering and technical organizations
A. W. Newton, representing engineering and other technical organizations.

Other Members

Guy Gray, representing retailers, Gray Lumber Company
Adolph Pfund, representing retailers, National Retail Lumber Dealers Assn.
Charles Hill, representing manufacturers, A. C. Tuxbury Lumber Company
L. Germain, Jr., representing wholesalers
John Foley, representing railroads, Pennsylvania Railroad System
E. A. Frink, representing railroads
Henry Ericsson, representing general contractors
Arthur E. Lane, representing American Wholesale Lumber Association
E. J. Curtis, representing wood-using industries
R. E. Brown, representing the Society of Automotive Engineers
J. M. Pritchard, representing Hardwood Manufacturers Institute.

As a result of one of the important decisions of a recent meeting, Mr. Compton, as chairman, will assign to individuals and groups of individuals, selected from the membership of the Consulting Committee, various phases of the problem of lumber standardization and simplification for investigation and recommendation. Their findings will be reported to the whole Consulting Committee.

Although conclusions regarding standardization in lumber-grading nomenclature and the marking of standard grades on lumber must necessarily await conclusions on grade standardization, they are now a subject for the consideration of the Consulting Committee. Grade marking can be undertaken on the present grades without awaiting conclusion of more uniform standards. Similarly improved and more uniform inspection service is closely related to grade standardization. These are, however, matters of immediate concern to lumber manufacturers and shippers and as a consequence may not require the consideration of the entire Consulting Committee.

The outline of immediate activities of the Consulting Committee includes careful consideration of the following:

1. Yard Lumber Sizes
2. Molding Patterns
3. Standard: (*a*) species; (*b*) use; (*c*) size; (*d*) manufacturing classifications of lumber.
4. The Forest Products Laboratory plan for investigation of softwood shop, and hardwood, lumber grading; and such consideration as the Consulting Committee may desire to give to the following:
5. Application to grading rules of Suggested Basic Rules for Grading Softwood Yard Lumber and Structural Timbers
6. Grade Marking
7. Use of Tally Cards
8. Inspection Service
9. Standard Names for Lumber Grades.

The suggested provision in lumber-grading rules for the admissibility of certain percentages of short lengths and odd lengths of lumber has been submitted to the constituent associations together with an analysis of information, and opinion thereon, prepared by the executive secretary.

Standardization in the Marine Field

THE general committee on Standardization recently formed by the American Marine Association has adopted a plan of organization which will enable it to establish standards in the marine field comparable with the work of similar organizations in other fields both here and abroad but entirely independent of them. The purpose of this movement is to give the marine industries of the United States the benefit of established and recognized standards for hull details and operation details. Both of these will reduce the cost of ship construction and operation and will thus help to place competition with foreign shipping on more equal terms.

The third meeting of the general committee was held in New York on April 17 with Captain R. D. Gatewood, U. S. N., as acting chairman. At this meeting it was resolved that the standardization and simplified-practice project in the marine field be carried on under the name of the "American Marine Standards Committee."

The purpose of the American Marine Standards Committee is in line with the movement inaugurated by Secretary Hoover of the Department of Commerce to eliminate waste and reduce costs. The extension of this work to the marine industries was proposed by him at the annual Marine Exposition in New York last Novem-

ber and was taken up by the American Marine Association with the support of the Department of Commerce and the United States Shipping Board Emergency Fleet Corporation.

In order to carry out the work expeditiously and economically, the committee has adopted a plan of organization in which the American Marine Standards Committee will act as the executive committee, all details and correspondence being carried out through the office of its secretary in the Division of Simplified Practice of the Department of Commerce in Washington.

The work of the organization will be administered primarily by three committees as follows:

A Organization, Membership and Finance
B Constitution and Rules
C Publicity and Relations.

The policies of these committees will be carried out by the secretary.

The following were appointed as members of the three administrative committees:

Committee A

COL. E. A. SIMMONS, *Chairman*, President, American Marine Association
CAPT. C. A. MCALLISTER, *Vice-Chairman*, Vice-President, American Bureau of Shipping
CHARLES F. BAILEY, Engineering Director, Newport News Shipbuilding and Dry Dock Company
HUGO P. FREAR, Naval Architect, Bethlehem Shipbuilding Corpn., Ltd.
E. H. RIGG, Naval Architect, New York Shipbuilding Corpn.

Committee B

WILLIAM F. GIBBS, *Chairman*, President, Gibbs Brothers
E. H. RIGG, *Vice-Chairman*, Naval Architect, New York Shipbuilding Corpn.
CAPT. JOHN F. MILLIKEN, Secretary, Neptune Association
JOHN W. GRAY, Newport News Shipbuilding and Dry Dock Company
CAPT. C. A. MCALLISTER, Vice-President, American Bureau of Shipping.

Committee C

CAPT. C. A. MCALLISTER, *Chairman*, Vice-President, American Bureau of Shipping
CAPT. R. D. GATEWOOD, *Vice-Chairman*, U. S. N., United States Shipping Board Emergency Fleet Corporation
COL. E. A. SIMMONS, President, American Marine Association
JOHN W GRAY, Newport News Shipbuilding and Dry Dock Company
CAPT. JOHN F. MILLIKEN, Secretary, Neptune Association.

Under Committee A (on organization) three technical supervisory committees will be created as follows:

1 Committee on Hull Details
2 Committee on Engineering Details
3 Committee on Ship Operating Details and Consummable Supplies.

Through each of these technical supervisory committees there will be formed a large number of subject committees to which will be assigned the task of studying and formulating a standard for such specific items as will from time to time be designated by the executive committee. At the April meeting the committee confirmed the appointment of A. V. Bouillon as its secretary.

LIBRARY NOTES AND BOOK REVIEWS

Sampling and Analysis of Coal, Coke and By-Products

SAMPLING AND ANALYSIS OF COAL, COKE AND BY-PRODUCTS. Methods of the U. S. Steel Corporation. Second edition, 1923. Published by The Carnegie Steel Company, Pittsburgh, Pa. Leather, 5 × 7³/₄ in. 184 pp., illus., tables, $3.

REVIEWED BY C. P. MENGES,[1] NEW YORK, N. Y.

THIS little book contains a collection of the methods of sampling and analysis of coal and its derivatives to be used as a guide for its evaluation as a fuel or by-product, and compares very well with the best literature on this subject.

The methods chosen are those which have recently been found to be the most accurate and rapid and which can be followed out in most analytical laboratories. Numerous standard methods outlined in this volume were taken from the proceedings of the American Society for Testing Materials and the Bureau of Mines, where both chemical and physical tests on this subject have been carefully investigated. Also a number of special tests by different authors are quoted.

In reviewing that part of the work in which no outside references are made, a similarity of methods is noticed to those found in the best chemical literature and textbooks from which the fundamental methods were taken, with the addition of such tests and apparatus as special investigators on this subject have found to be of additional value in the examination of these various products.

Alternative methods are frequently given, so that there is a choice as regards the kind of apparatus at hand and the time required to make the analysis.

In conclusion it may be said that the book is complete in itself. The preparation of the standard solutions necessary to make the analysis are described in detail, and also the various tables required for the calculations are included, so that the necessity of consulting other books is eliminated.

AUTOMOBILE CHASSIS. By Ben G. Elliott. McGraw-Hill Book Co., New York and London, 1923. Cloth, 5 × 8 in., 233 pp., illus., $2.50.

A textbook for students of automotive engineering. Treats all parts of the gasoline automobile, except the body, the power plant, and its immediate accessories. Particular stress is put upon fundamental principles. These are illustrated, as far as possible, by examples from modern practice, so that the work is useful for reference as well as for instruction.

[1] Chemist, New York Edison Company.

BUSINESS CYCLES AND UNEMPLOYMENT. Report and Recommendations of a Committee of the President's Conference on Unemployment. McGraw-Hill Book Co., New York and London, 1923. Cloth, 6 × 9 in., 405 pp., charts, tables, $4.

Report of an investigation of the whole problem of unemployment and of methods of stabilizing industry so that business depressions would be prevented. This volume contains also the report of an investigation made, at the request of the Committee, by the National Bureau of Economic Research. The latter report discusses the relation of business cycles to unemployment, cyclical fluctuations in employment, and proposed remedies for cyclical unemployment.

CONSOLIDATED TEXTILE CATALOGS, 1923. Compiled by *Textile World*. Bragdon, Lord & Nagle Co., New York, 1923. Cloth, 9 × 12 in., 531 pp., illus.

This catalog is intended to provide firms engaged in the textile industry with a conveniently arranged collection of catalog information, similar to that available for other lines. The book describes a large proportion of the textile machinery built in this country, the material being arranged under such heads as cotton machinery, wool and worsted machinery, knitting machinery, machinery for dyeing, drying and bleaching, power-plant equipment, mill supplies, building construction, etc. An index of firm names and an index of products are provided, together with a catalog of books on textiles.

COSGROVE'S HANDBOOK OF WOODWORKING MACHINERY. Cosgrove Company, Owosso, Mich., 1923. Loose leaf, fabrikoid, 8 × 11 in., $15.

Buyers of woodworking machinery will find in this handbook descriptions of the machines and equipment manufactured in this country, prepared in uniform manner and classified so that the different machines may be easily compared. The descriptions explain the principles of each machine, tell the sizes made and their capacities, state the power and floor space which they require, and give the names of the manufacturers. An index and a directory of manufacturers are included. The book is issued in loose-leaf binding, to permit the insertion of new matter.

Elasticity and Strength of Materials Used in Engineering Construction. Section 2, Theory of Simple Flexure. By C. A. P. Turner. Minneapolis, Minn., 1923. Cloth, 6 × 9 in., 108 pp., diagrams, $5.

The second section of Mr. Turner's work deals with the theory of flexure. The development of the exact theory of flexure will prove interesting to the profession, the author believes, as will also the simplified formulas. These are developed in such form that they can be remembered and used without reference to a handbook. The discussion of the stress analysis of beams shows clearly the relation of shear distortion to shear resistance, a relation frequently not understood.

Electric Cranes and Hauling Machines. By F. E. Chilton. Isaac Pitman & Sons, London and New York, 1923. (Pitman's technical primers.) Cloth, 4 × 6 in., 114 pp., illus., diagrams, $0.85.

The object of this book is to describe a number of the more generally used types of electric cranes and hauling machines, together with a few of the accessory specialties used with them, and to explain their methods of operation. The subject is treated in a simple, descriptive manner, on broad general lines. Only the most modern and commonly used appliances are included.

Electric Motors, vol. 1. Chiefly Concerning Direct Current. By Henry M. Hobart. Third edition. Isaac Pitman & Sons, London and New York, 1923. Cloth, 6 × 9 in., 412 pp., illus., diagrams, tables, $4.50.

An advanced treatise by an experienced designer, in which matters of theoretical and practical interest are discussed. The present edition has been completely revised and rewritten. While this volume is mostly about direct-current motors, the author has made no attempt to separate alternating- and direct-current questions sharply, and has included certain important matters in the second volume.

English and Engineering. By Frank Aydelotte. Second edition. McGraw-Hill Book Co., New York and London, 1923. Cloth, 5 × 7 in., 415 pp., $2.

Dr. Aydelotte sets forth the purpose of his book to be to teach the student to write by stimulating him to think for himself about his own problems, about his work, and its place in the world.

The range of the thirty-eight essays in the book embraces many kinds of men and many kinds of writing—from the works of Macaulay and Ruskin to the writings of living engineers and advertisements of manufacturers.

Financial Incentives for Employees and Executives. By Daniel and Meyer Bloomfield. 2 vols. H. W. Wilson & Co., New York, 1923. (Modern Executive's Library.) Cloth, 5 × 8 in., $4.80.

A handy compilation of articles on wage systems, bonus plans, thrift plans, and other plans for rewarding employees, classified and arranged for convenient reference. Part of the material is reprinted from periodicals and reports, the remainder is original with the authors. The work covers a wide field and gives the practice of many firms.

Hütte, des Ingenieurs Taschenbuch, vol. 1, 24th edition. By Akademischer Verein Hütte, Berlin. Wilhelm Ernst & Sohn, Berlin, 1923. Cloth, 5 × 7 in., 1308 pp., diagrams, tables, $2.

The present volume has been thoroughly revised to bring it abreast of modern practice. The section on the mechanics of rigid bodies has been entirely rewritten; that on the mechanics of fluids has been enlarged. Improvements have been made in the section on heat, especially in the chapter on combustion, and in the section on the strength of materials. The chapters on lubricants and on belts and belt conveyors have been rewritten. The section on machine elements has been rewritten and enlarged. Nearly 250 pages in all have been added to the book. A change has been made in the method of selling the book, so that the individual volumes can now be bought separately.

Industrial Electric Heating. By J. W. Beauchamp. Isaac Pitman & Sons, New York and London, 1923. (Pitman's technical primers.) Cloth, 4 × 6 in., 118 pp., illus., diagrams, tables, $0.85.

The primary object of this book is to bring together, for the benefit of the engineer and student, information on the applications of electric heating, particularly to other purposes than furnace and welding work. The book is intended to suggest possible applications and thus to stimulate further inquiry by manufacturers and others who could use electric heating, by calling attention to the variety of uses which it now has.

Interior Wiring and Systems for Electric Light and Power Service. By Arthur L. Cook. Second edition. John Wiley & Sons, New York, Chapman & Hall, London, 1923. Fabrikoid, 4 × 7 in., 458 pp., illus., diagram, tables. $3.

Intended as a guide to modern practice in electric lighting and power applications, and in the design and installation of the wiring for these purposes. Written particularly for superintendents of electrical installations and for wiremen who may be called upon to extend or change existing installations and who need definite information upon the best method of procedure. It is also intended as a textbook for students in trade schools and as a handbook for architects.

Kalender und Handbuch für Betriebsleitung und Praktischen Maschinenbau, 1923. By Hugo Güldner. 2 vols. H. A. Ludwig Degener, Leipzig, 1923. Limp cloth, 4 × 6 in., diagrams, tables, $1.

A pocketbook designed to meet the wants of engineers engaged in management and operation, or in the manufacture of machinery, rather than in design. Issued in two parts, the first containing the greater part of the text and discussing the materials of machines, machine parts, prime movers, power transmission and auxiliary machinery. Volume two treats of management and also contains mathematical tables. The work is published in inexpensive form and is revised each year.

Mechanical Testing, Vol. 2; Testing of Prime Movers, Machines, Structures and Engineering Apparatus. By R. G. Batson and J. H. Hyde. E. P. Dutton & Co., New York, 1923. (Directly useful technical series.) Cloth, 6 × 9 in., 446 pp., illus., diagrams, tables, $10.

This book, the concluding volume of this treatise on testing, deals with methods and apparatus for testing prime movers, machines and structures. The text is confined to descriptions of mechanical methods of testing, except in certain important cases where hydraulic, electrical, or optical means are employed to supplement mechanical means. Types of testing apparatus for the standard tests, suited for use both in the laboratory and the factory, are also described. Prominence is given to details of importance in the success of test apparatus.

Moedebeck-Taschenbuch für Flugtechniker und Luftschiffer. By R. Süring und K. Wegener. Fourth edition. M. Krayn, Berlin, 1923. Boards, 5 × 7 in., 920 pp., illus., diagrams, tables, $3.60.

This volume, intended to serve as a concise account of the present state of aerial navigation, suitable for ready reference. Its seventeen chapters are each prepared by an authority and are liberally illustrated with diagrams and photographs; many have short bibliographies. A collection of tables is appended to the book.

Origin and Development of the Quantum Theory. By Max Planck. Oxford University Press, American Branch, New York, 1922. Paper, 6 × 9 in., 22 pp. $1.20.

This is the Nobel Prize address delivered before the Royal Swedish Academy of Sciences, June 1920. It sketches briefly the history of the origin of this important theory and gives a short account of its development and its influence on present-day physics. A brief bibliography is given.

Professor Coker's Apparatus for Determining the Distribution of Stress in Structural and Machine Members. Made by Adam Hilger, London.

This pamphlet is a trade publication describing the apparatus devised by Prof. E. C. Coker for using polarized light to determine the distribution of stress in parts of machines and structures by observations on models made of transparent materials; a method that makes it possible to measure the stress distribution under any system of loads, in any body that can be represented by a plate model stressed in its own plane. As the measurements obtained on models with this apparatus have been found to represent accurately the stresses in metals, the experimental results can be immediately applied to engineering materials. A bibliography is included.

THE ENGINEERING INDEX

(Registered United States, Great Britain and Canada)

Exigencies of publication make it necessary to put the main body of The Engineering Index (p. 117-EI of the advertising section) into type considerably in advance of the date of issue of "Mechanical Engineering." To bring this service more nearly up to date is the purpose of this supplementary page of items covering the more important articles appearing in journals received up to the third day prior to going to press.

AIR FURNACES

Oil-Burning. Melts with Oil in Air Furnace, D. I. Dobson. Foundry, vol. 51, no. 11, June 1, 1923, pp. 435–437 and 466, 1 fig. Coal-burning furnaces used to melt malleable with slight changes in combustion chamber; figures given showing relative cost of coal and oil firing; oil consumption recorded.

Jet Propulsion. Jet Propulsion for Airplanes, Edgar Buckingham. Nat. Advisory Committee for Aeronautics—Report, no. 159, 1923, 18 pp., 8 figs. Discusses method for propulsion by reaction of internal-combustion jet; only hope of success is said to lie in thrust augmentors.

Low-Powered. The Low-Powered Aeroplane, W. H. Sayers. Aeroplane, vol. 24, nos. 18, 19 and 20, May 2, 9 and 16, 1923, pp. 323–324, 343–344 and 363–366, 2 figs. General consideration in light of present developments. May 9: Speed and power; cleanness; weight; wings and body resistance. May 16: Effect of 1 gal. fuel limit; effect of body; engines for light airplanes.

AUTOMOBILE ENGINES

Triumph-Ricardo. Novel Cylinder Block and Crankcase in New British Light Car, M. W. Bourdon. Automotive Industries, vol. 48, no. 20, May 17, 1923, pp. 1078–1080, 6 figs. 4-cylinder engine designed by Ricardo for Triumph car; masked inlet valve and slipper pistons are features; two-bearing crankshaft, splash lubrication, and integral inlet and exhaust manifolds used; bore, $2^1/_2$ in. and stroke, $4^3/_8$ in.

AUTOMOBILES

Wheels. Making Welded Pressed-Steel Automobile Wheels. Machy. (N. Y.), vol. 29, no. 10, June 1923, pp. 757–761, 8 figs. Methods and equipment employed in making automobile and truck wheels by new process.

BLAST FURNACES

Linings, Disintegration of. Solving Furnace Lining Problems, C. E. Nesbitt and M. L. Bell. Iron Trade Rev., vol. 72, no. 22, May 31, 1923, pp. 1603–1607, 7 figs. Laboratory tests are conducted on firebrick for blast furnaces to determine cause of disintegration and its prevention; hard burning is helpful but not desirable; iron-free clay must be used. (Abstract.) Paper presented at Am. Iron & Steel Inst.

BOILER FURNACES

Design. The Influence of Radiant Heat on Furnace Design, A. G. Christie. Power, vol. 57, no. 22, May 29, 1923, pp. 851–854. By simple analogies author pictures behavior of radiant heat waves and their effect on various substances, leading up to analysis of radiant heat in boiler furnaces; suggests designing furnace with maximum amount of boiler-tube surface exposed to fire in order to take up greater amount radiant heat.

BRAKES

Kunze-Knorr. The Kunze-Knorr Air Brake. Ry. & Locomotive Eng., vol. 36, no. 5, May 1923, pp. 143–147, 10 figs. Describes recent German development based on principle of single-cylinder automatic compressed air brake. See also editorial, pp. 149–150.

CAMS

Internal-Combustion-Engine. Internal-Combustion Engine Cams, B. B. Low. Engineering, vol. 115, no. 2995, May 25, 1923, pp. 641–644, 12 figs. Gives mathematical analysis of cams most generally used in internal-combustion engines and considers definite examples showing relative merits as regards average lift, spring strength, noise, etc., of different types.

CENTRAL STATIONS

Diesel-Powered. The Diesel-Powered Central Station. Power, vol. 57, no. 22, May 29, 1923, pp. 856–858, 6 figs. Cites examples where Diesel engine has shown economies impossible with steam units. There are 1100 oil-engine-powered light plants in United States.

COAL

Carbonization. Coal Carbonization as Applied to Power-Plant Practice, V. Z. Caracristi. Power, vol. 57, no. 22, May 29, 1923, pp. 831–836, 4 figs. Low-temperature system of coal distillation; working temperature of oven 1200 deg.; distillation completed in five minutes; coke obtained suitable for boiler firing, powdered fuel or briquetting into domestic fuel.

COST ACCOUNTING

Overhead. Taking the Guesswork out of Overhead Costs, Dale S. Cole. Indus. Management (N. Y.), vol. 65, no. 6, June 1923, pp. 324–326, 1 fig. Shows simple, inexpensive method which permits of more intelligent estimating by small plant, laying particular stress on items of "contributory overhead."

DIE CASTING

Dies. Die-Casting Dies and Their Design, Charles Pack. Machy. (N. Y.), vol. 29, no. 10, June 1923, pp. 804–806, 7 figs. Describes most important points of design and construction in number of die-casting dies, showing methods that may be employed for die-casting white metals into parts of various designs.

DROP FORGINGS

Coarse-Grained. Coarse-Grained Drop Forgings—Their Detection and Correction, L. S. Cope. Am. Soc. Steel Treating—Trans., vol. 3, no. 8, May 1923, pp. 808–823, 28 figs. Review of factors which chiefly contribute to coarse-grained structure, most important of which are excessively high forging temperatures with insufficient amount of mechanical work; discusses methods of detecting coarse-grained fractures and describes method devised by author which has proven satisfactory; importance of proper furnace design, heating temperatures and reductions in hammering metal into dies.

ELECTRIC FURNACES

Gray Iron. Melts Gray Iron by Electric Furnace, G. K. Elliott. Iron Trade Rev., vol. 72, no. 21, May 24, 1923, pp. 1535–1537. Outlines main features of acid and basic electric furnaces, sketches effects upon principal elements of cast iron in comparison with effects obtained through cupola, and discusses problems of cast iron that have arisen through introduction of electric furnace for treating cast iron. (Abstract.) Paper read before Am. Foundrymen's Assn.

ELECTRIC LOCOMOTIVES

4000-Hp. New Electric Locomotives for the Norfolk & Western R. R., T. C. Wurts. Ry. & Locomotive Eng., vol. 36, no. 5, May 1923, pp. 153–155, 4 figs. Features include cab structure carried by side frames; four pairs of drivers in single truck per cab; single 1000-hp. motor per jack shaft; oil-insulated force-cooled transformer; unique arrangement to reduce torque on any motor to present slipping. See also description in Ry. Elec. Engr., vol. 14, no. 4, May 1923, pp. 137–140, 5 figs.

ELECTRIC WELDING, ARC

Manufacturing Purposes, Use for. Arc Welding as a Manufacturing Asset, J. F. Lincoln. Elec. World, vol. 81, no. 20, May 19, 1923, pp. 1147–1148, 1 fig. Points out that arc welding can be of greatest service in manufacture of parts which are usually made of cast iron, and gives examples; also enumerates the advantageous features of properly arc-welded joint.

EMPLOYEES, TRAINING OF

Plans. How Labor Can Be Made More Productive, Harold C. Smith. Am. Mach., vol. 58, no. 22, May 31, 1923, pp. 793–796. Educational activities of Nat. Metal Trades Assn. Five plans for training workers; purpose of industrial training.

EMPLOYMENT MANAGEMENT

Personnel Practice. Present Tendencies in Personnel Practice, Robert F. Lovett. Indus. Management (N. Y.), vol. 65, no. 6, June 1923, pp. 327–333, 2 figs. Study of personnel procedure in 74 industrial and commercial concerns.

FACTORIES

Building Planning. Buildings from The Manager's Viewpoint, G. L. H. Arnold. Management Eng., vol. 4, nos. 5 and 6, May and June 1923, pp. 329–333 7 figs., and 417–421, 10 figs. May: Foundation, floors, and ceiling for well-planned factory. June: Planning roof; partitions, doors, and equipment.

FLOW OF WATER

Electrical Measurement. Electrical Measurement of Velocities of Flow in Pipes, Ivan E. Houk. Engineering, vol. 115, no. 2995, May 25, 1923, pp. 644–645, 3 figs. Describes typical method of measurement based on principle of sudden change in electrical properties of fluid which occurs when charge of salt is inserted; method consists of observing time required for such charge to pass through measured length of pipe, adding salt at intake end, or some other convenient place. Method was used by Miami Conservancy District.

FURNACES, HEAT-TREATING

Electrically Heated. Heat Treat to Remove Strains, Pat Dwyer. Foundry, vol. 51, no. 11, June, 1 1923, pp. 429–432, 5 figs. Large turbine frames and other castings of similar character are heat-treated in special electrically heated oven in which casting is raised to approximately 700 deg. Fahr.; describes foundries of General Electric Co. at Schenectady, N. Y.

GEARS

Automobile Non-Metallic. Study of Material and Methods Needed in Non-Metallic Gear Production, J. Edward Schipper. Automotive Industries, vol. 48, no. 20, May 17, 1923, pp. 1084–1086, 4 figs. Quiet gear-driven front end obtained; tests with typical product indicate blanks are more expensive than metallic type; fewer tear-downs and easier inspection offset extra cost.

HYDRAULIC TURBINES

Draft Tubes. Results of Tests on Five Types of Draft Tubes. Power, vol. 57, no. 22, May 29, 1923, pp. 859–862, 6 figs. Tests conducted for purpose of securing comparison of performance between older forms of elbow draft tubes, type of recently developed and new symmetrical types of draft tubes.

HYDROELECTRIC PLANTS

Automatic. Automatic Plants Aid Western Water-Power Development, E. R. Stauffacher and Gustaf Clinwald. Elec. World, vol. 81, no. 22, June 2, 1923, pp. 1257–1259, 3 figs. Nine semi-automatic generating plants, with total rating of 14,655 kw. now in operation on Southern California Edison system; operating costs reduced approximately 45 per cent.

INDUSTRIAL MANAGEMENT

Cost Control. Managerial Control Through Costs, J. P. Jordan. Management Eng., vol. 4, nos. 2, 3, 4, 5 and 6, Feb., Mar., Apr., May and June, 1923, pp. 81–86, 169–176, 235–240, 335–340 and 399–404, 10 figs. Feb.: Managerial control with direct personal knowledge, without either direct or indirect personal knowledge, and with indirect personal knowledge. Mar.: Cost control. Apr.: Use of general expense accounts. May: Use of departmental burden accounts. June: Keeping up cost reduction.

Greater Production. How Management Can Be Made More Productive, Acheson Smith. Am. Mach., vol. 58, no. 23, June 7, 1923, pp. 831–834. What "greater production" means and why it is necessary; influence on prosperity of scarcity of labor; specific lines of effort that management should follow.

LOCOMOTIVES

Oil-Burning. Mountain and Mikado Types for the Frisco. Ry. Age, vol. 74, no. 24, May 19, 1923, pp. 1207–1208, 2 figs. New oil-buring locomotives based on U. S. R. A. designs modified to suit railroads' standards.

OIL ENGINES

Hot-Bulb. The Penney-Porter Heavy Oil Engine. Engineering, vol. 115, no. 2995, May 25, 1923, pp. 652–653, 6 figs. Describes two-cycle engines of hot-bulb type for land and marine use.

Solid-Injection. A Solid-injection Crude Oil Engine. Engineer, vol. 135, no. 3516, May 18, 1923, pp. 523–524, 3 figs. New horizontal type of crude-oil engine, working on 4-stroke cycle, and made with single and twin cylinders in several sizes; feature of engine is facility with which it can be changed over for working with gas instead of oil as fuel.

OPEN HEARTH FURNACES

Reversing Valves. New Type of Open-Hearth Reversing Valve, John Nelson. Iron Age, vol. 111, no. 22, May 31, 1923, pp. 1560–1561 and 1610, 3 figs. Isley combination air and gas-reversing valve is self-contained and all above ground; permits regulation of gas and air supply; without internal moving parts.

PRODUCER GAS

Metallurgical Use. Making Efficient Producer Gas, Waldemar P. G. Dyrssen. Iron Trade Rev., vol. 72, no. 23, June 7, 1923, pp. 1677–1682, 2 figs. Practice as it concerns production of fuel for metallurgical use; theoretical and actual results are compared; modern types of producers designed to provide gas in constant volume and quality. (Abstract.) Paper presented at Am. Iron & Steel Inst.

STEAM-ELECTRIC PLANTS

Detroit Edison Co. New Marysville Plant, Detroit Edison Co., C. Harold Berry. Power, vol. 57, no. 22, May 29, 1923, pp. 824–830, 8 figs. Contains two turbo-generators, one of 10,000-kw. and other of 30,000-kw. capacity, served by four boilers, each having 28,212 sq. ft. of effective heating surface.

Hell Gate, New York. Operating Methods at Hell Gate. Power Plant Eng., vol. 27, no. 11, June 1, 1923, pp. 555–564, 12 figs. Large boiler units impose certain limitations on operating methods; heat-balance control under one operator; station records and test facilities are unusually complete; coal-handling system serves seceral stations; ash handling by sluices.

STEAM POWER PLANTS

Benson Super-Pressure. The Benson Super-Pressure Plant—Its Scientific Basis, P. W. Swain. Power, vol. 57, no. 22, May 29, 1923, pp. 842–846, 6 figs. Study of scientific principles underlying this and other systems for production and utilization of high-pressure, high-temperature steam; Mollier and temperature-entropy diagrams are used in investigating possibilities of various methods of operation.

STEEL MANUFACTURE

Waste-Heat Utilization. Reducing Waste in Steelmaking, H. T. Morris. Iron Age, vol. 111, no. 22, May 31, 1923, pp. 1600–1602. Utilizing heat waste in steel works is said to offer possibilities for improved efficiency; electrification an important factor in eliminating driving energy losses; standardization a valuable method of fighting waste. (Abstract.) Paper read before Am. Iron & Steel Inst.